A

PRACTICAL TREATISE

ON FINDING THE

LATITUDE AND LONGITUDE

AT SEA.

Hartnell, Printer,
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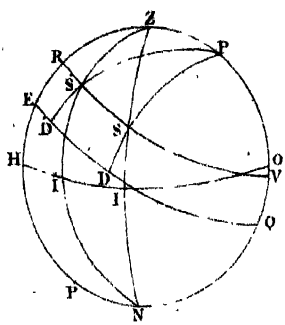
Nautical Astronomy.

Fig. 1.



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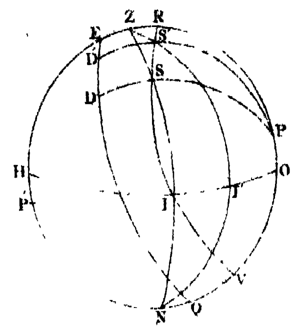

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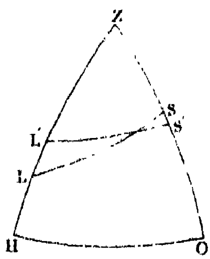

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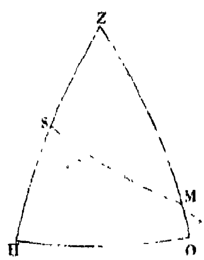

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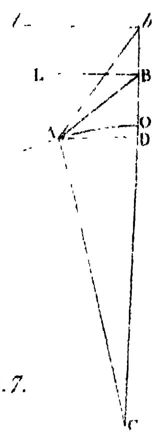

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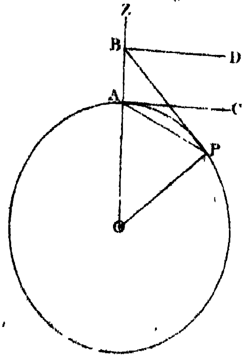
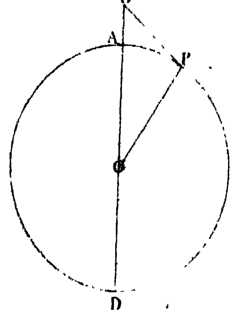


Fig. 7.



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PRACTICAL TREATISE

ON FINDING THE

LATITUDE AND LONGITUDE,

AT SEA;

WITH TABLES DESIGNED TO FACILITATE THE

CALCULATIONS.

TRANSLATED FROM THE FRENCH OF

M. DE ROSSEL,

Member of the French Board of Longitude, late Captain in the Navy, &c &c. &c.

BY THOMAS MYERS, A. M.

OF THE ROYAL MILITARY ACADEMY, WOOLWICH,

AND

HONORARY MEMBER OF THE PHILOSOPHICAL SOCIETY OF LONDON

TO WHICH ARE SUBJOINED, AN EXTENSIVE SERIES OF

Practical Examples,

AN

INTRODUCTION TO THE TABLES,

AND

SOME ADDITIONAL TABLES,

BY THE TRANSLATOR.

LONDON:

PRINTED FOR G. AND S. ROBINSON, PATERNOSTER-ROW,

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1815

PREFACE.

In a country whose political and commercial interests are so inseparably connected with her naval prosperity, as in Britain, an attempt to render a correct knowledge of Navigation more easy and accessible to her mariners, merits encouragement rather than demands apology. Daily experience also proves that numbers of young men, after having spent several years in the service, are but very imperfectly acquainted with the scientific principles of their profession. Under the influence of these impressions, united with a desire to remove this defect as much as possible, the subsequent work was undertaken. With respect to the Treatise on Nautical Astronomy which forms its bases, the learned French astronomer, M. Biot, to the second edition of whose "*Traité élémentaire d'Astronomie Physique*" it forms an important addition, thus describes the nature of the work, and the qualifications of its author.

"There is one branch of Astronomy (says he) which has never been treated in a convenient manner in elementary works, because this required great accuracy and simplicity joined to an experience beyond what most men have an opportunity

of acquiring. This is Nautical Astronomy; which has either been treated too superficially or in much too scientific a manner for mariners. I have, however, been very fortunate in having this part added to my work, by one who ranks among those who are best qualified to write on the subject. This is M. de Rossel, late Captain in the French Navy, coadjutor in and writer of the voyage of *d'Entrecasteaux.* The observations made by M. de Rossel and the other officers, during the voyage, have generally been regarded as the most accurate ever made in any French maritime expedition; and M. de Rossel's discussion of them as constituting an excellent Treatise on Nautical Astronomy. It is a Treatise of this kind, but more simple and concise, which this author has added to my work. It will be found to contain all the methods of calculation requisite at sea, and, what is not less valuable, they are given under the most simple and commodious forms that can be employed in their application. Mariners will not fail to remark the ingenious tables which M. de Rossel has calculated for facilitating the use of Douwe's method of finding the latitude from two observations of the sun taken out of the meridian. This method, which may frequently be of great utility, is rendered so easy and convenient, by these tables, that its use will doubtless become familiar to all mariners."—It is but justice to MM. Biot and Rossel, to add, that the Translator

has been favoured with a confirmation of this statement from a gentleman whose personal knowledge afforded him many opportunities of appreciating the talents and qualifications of M. de Rossel, during the period he was in the service of the British Admiralty.

To render the work more complete, and better adapted for perfecting the young mariner in the most difficult branches of his art, the Translator has added an extensive series of practical examples, and an Introduction to the Tables, explanatory of their construction and use; with a Table of the Right Ascensions and Declination of the principal fixed stars, used in finding the longitude at sea, and another of the logarithms of numbers and their complements, to an extent sufficient for the work. To these he has likewise subjoined a Table, the logarithmic sines and cosines with their complements, and differences for every 10 seconds of a degree, and also the logarithmic tangents and cotangents, with their differences corresponding to every 10 seconds. These, he trusts, will be found more convenient than the logarithmic tables in common use. A new and easy method of clearing the distance, lately published by the Rev. Dr. Brinkley, Professor of Astronomy in the University of Dublin, has likewise been added to the present work, and accompanied by a Table of Natural Versed Sines, by means of which the solution of this troublesome problem is greatly facilitated.

From this brief explanation, it will readily be perceived that the object of this Treatise is two-fold. First; to furnish mariners with an accurate work, containing the most simple and commodious methods of calculating their position on the globe at any given instant, with the assistance of the Nautical Almanac ONLY. The second is that of supplying the young navigator with an extensive series of *new* and practical examples, the solutions of which will gradually unfold the scientific principles of his profession, and familiarize him with their application. With this view, the work of one of the examples corresponding to each rule, has been inserted at full length, as a specimen of the method of working those to which the answers only are given. These examples have also been principally adapted to the years 1814 and 1815; by which means, a Nautical Almanac of a proper date will, for a considerable time, be constantly at hand.

Great care has been taken to avoid errors, both in the formation and solution of these examples; and they are now submitted, with greater confidence, to those who are accustomed to such calculations, from a firm persuasion that, should any error be discovered, the liberal and enlightened British mariner will ever be more ready to *correct* than to condemn.

Royal Military Academy, Woolwich,
April, 1815.

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INTRODUCTION TO THE TABLES,

Explanatory of their construction and use.

ERRATA.

The word logarithm, instead of logarithmic, having been printed in several places, by mistake, the reader is requested to make the necessary correction mentally.

Page 40, line 2, *dele the.*
69, —— 3, *for* logariths *read* logarithms.
220, ——10 from bottom, *for* 5 *read* 5th.
250, last line of the note, *for* 8 *read* 8″; and add the word *Translator* to the end of the note.

INTRODUCTION TO THE TABLES.

Page i line 4 from bottom, *for* BP *read* BD.
iii —— 3 from top, *for* fig. 6 *read* fig. 7.

A TREATISE,

&c. &c.

CHAPTER I.

Preliminary Observations, and Methods of finding the given Quantities of the Calculations in the Nautical Almanac, or The Connaissance des Tems.

1 Astronomy teaches us to calculate the motions of the heavenly bodies, and to ascertain the places which they ought to occupy in the heavens at any given instant. Nautical Astronomy is one of the most useful branches of this vast science; its object is to furnish navigators with the means of knowing the position which their zenith ought to have in the heavens, with respect to those heavenly bodies, the situations of which have been made known by astronomers. It prescribes simple and easy rules, by the assistance of which they may ascertain their position on the globe, or their latitude and longitude.

2. Latitude is an arc of the terrestrial meridian comprised between any place and the equator; it is, consequently, the distance of the place from the equator measured in degrees; and is called *North latitude* when the place is situated in the northern hemisphere; and *South latitude* when it is situated in the southern hemisphere.

3. Longitude is an arc of the equator contained between the meridian of any place and that of another, which is called the *first meridian*. It is generally reckoned towards the east and west, from 0° to 180° through each half of the equator. The longitude of all the meridians situated eastward of the first meridian is styled *East longitude*; and that of those meridians on the west of it, is called *West longitude*.

There is not any circle on the earth's surface, the position of which is fixed like that of the equator, and from which the commencement of longitude can be reckoned; and therefore any meridian may be taken at pleasure for the first. The different nations of Europe have adopted the meridian of the principal place where they observe the motions of the heavenly bodies, and to which each is accustomed to refer their positions: it is generally this meridian for which their Ephemerides are computed. The French reckon their longitude from the meridian of Paris, and the English from that of the Royal Observatory, at Greenwich. There is not, therefore, any absolute longitude, properly speaking: it is only the difference of longitude that can be ascertained, which, as already observed, is equal to the arc of the equator comprised between the meridians of the two places, the positions of which are compared; or, which is still the same, to the spherical angle formed by the meridians of these places.

4. Astronomers generally calculate the situations of the heavenly bodies with respect to the ecliptic; but observations can only give them directly in relation to the equator; they are equally obliged, in calculating from observations, to employ the elements, which serve to fix these positions with regard to the equator; and, in Nautical Astronomy, the declinations and right ascensions of those bodies only are used.

5. Declination is the distance of a heavenly body from the equator, measured on a great circle perpendicular to the equator, which is called the circle of declination. It may be

considered as a *celestial latitude*, and, consequently, might be called by that name. Declination is north, when the body is in the northern hemisphere; and south, when in the southern hemisphere.

The circles of declination, being perpendicular to the equator, ought to pass through the poles of that circle, and to have analogous and corresponding positions in the heavens to those of the meridians on the globe. Thus, when a heavenly body passes the meridian of any place its circle of declination is immediately above that meridian, and in the same plane with it. If, at that instant, the arc of the circle of declination, or of the celestial meridian, comprised between the body and the zenith of the observer, be measured, or otherwise, if the altitude of the body, which is the compliment of the zenith distance, be observed, it will be easy to ascertain the latitude. In fact, the declination of the body, or its distance from the equator, being given in the Ephemerides, it is evident that the distance of the observer from the same circle, or his latitude, will be equal to that declination plus or minus the distance of the body from the zenith of the same observer. The altitude, which is directly obtained from observation, may also be employed, instead of the zenith distance: the calculation is a little different, as will be subsequently seen, but the result is the same.

6. Right ascension is an arc of the celestial equator, comprised between the circle of declination of any heavenly body and the point where the ecliptic cuts the equator, and the sun commences his revolution: this is called the vernal equinoctial point. Right ascension may, therefore, be regarded as a *celestial longitude*, with this difference, that, in the heavens, there is a point fixed by nature, from which to begin the reckoning; but, on the earth, the first meridian must be arbitrarily assumed, from which the computation of terrestrial longitude commences. But the analogy is accurate between the difference of longitude and that of right

ascension; for this last is equal to an arc of the equator comprised besween two circles of declination, or *celestial meridians*, or to the spherical angle formed by those circles. The difference of longitude of any two places on the surface of the earth, is, therefore, equal to the difference of right ascension of the two circles of declination which correspond to the meridians of those two places, and which are, consequently, in the same planes with them.

7. This last consideration furnishes a new means of measuring terrestrial longitudes; it is derived from the diurnal motion of the earth, or its revolution on its axis. The duration of a day, or twenty-four hours, is the time in which the earth makes one revolution with respect to the sun, which is equal to the time that elapses between the passage of the sun over any meridian, and his return to the same meridian: twenty-four hours, therefore, corresponds to 360° of longitude or right ascension. Now, supposing the sun to be on the first meridian, all places situated on that meridian reckon noon at the same time; but those places on the other half of the same great circle diametrically opposite to the first meridian, that is, the places situated on another meridian 180° distant from the first, reckon midnight, or twelve hours less, at the same instant: therefore, 180° of longitude correspond to twelve hours of time. The great circle which passes through the poles, and has its plane perpendicular to that of the first meridian, forms two other meridians; one of which 90° to the east, and the other 90° to the west of the first. All places situated on that to the west, reckon six hours less than those on the first meridian; the astronomical day will therefore not have commenced at them, and it will be effectively only the 18th hour of the preceding day. Those places that are situated on the meridian 90° east of the first, reckon six hours more than at this last, and have the sixth hour of the day which has commenced at them: 90° of longitude, therefore, answer to six hours of time. These 90°,

or a fourth of the equator, may be supposed to be divided into six equal parts, each of which will be 15°, and from this, it is concluded, that 15° of longitude correspond to one hour of time; hence 1° answers to the fifteenth part of an hour, or four minutes. By continuing the subdivision, it will be found, that 15′ of a degree answer to 1′ of time, and 15″ of a degree to 1″ of time. Thus, longitude, or rather the difference of longitude, may be reckoned in time, at the rate of 15° to an hour.

8. Those places which are situated on a meridian 90° west of the first meridian, reckon, as already observed, six hours less than those in the first meridian; those that are 75 west, reckon five hours less; and those at 15° count one hour less. Generally, at all places of west longitude, the time is less than on the first meridian, by a number of hours and minutes equal to the longitude of those places converted into time. Hence, whenever we wish to know the hour which ought to be reckoned on any meridian west of that where we are, the difference of longitude reduced into time, must be subtracted from the hour at this latter place.

9. Those places that are situated on a meridian 90° eastward of the first meridian, reckon six hours when it is noon at this last, they, therefore, reckon six hours more. Thus, in order to obtain the hour at any meridian 90° east of the first, the longitude, reduced into time, must be added to the hour at this last. Generally, when the time is required that ought to be reckoned at places situated to the east of the meridian where we are, the time answering to the difference of the longitude corresponding to the two places must be added to the hour at this last meridian.

10. The problem of longitude, therefore, consists in finding directly by observation, the hour at the place where we are, and the hour which is reckoned on the first meridian, or on any other meridian, of which the longitude is known. It is easy to obtain the hour at any place by means of the alti-

tudes of the heavenly bodies; the hour at the first meridian is obtained by observations of the distances between the moon and the sun or the stars. The time at the first meridian, or at any other, is also obtained by marine chronometers; but as these machines are liable to experience slight derangements in their movements, they can only be depended upon during a certain lapse of time, and should be verified as often as possible. In general, they are more proper for ascertaining the difference of longitude of two places not far distant from each other, than for determining absolute longitudes.

The detail of the various operations which are necessary for calculating the latitude, the hour at any place where observations have been made, and its longitude, will be subsequently given; and the methods of obtaining the azimuths, which serve to make known the variation of the magnetic needle, will also be treated of. The altitudes of the heavenly bodies, and their distances, are the only data which can be obtained in a direct and precise manner by observation; but they are not sufficient for calculating the required quantities: the declinations and right ascensions, which fix the positions of these bodies in the heavens, must also be used, as well as several other elements which are found in Ephemerides. It will, therefore, be necessary, first, to show the methods of calculating these elements. The values of these different quantities change every instant, and are only predicted for the time at the first meridian; that time must therefore be calculated. It ought to be remarked, according to what has been said, that, previous to entering upon the calculations, we are obliged to suppose, that the longitude of the place of the observation is known. The declinations and right ascensions, with the other elements that are taken from the Nautical Almanac, or the Connaissance des Tems, partake, indeed, of the error of the longitude that has been employed in calculating the time at the first meridian; but that

of the results will always be so small, that it may be regarded as nothing. The rules that have been given in articles 8 and 9, for calculating the time at the first meridian, are therefore to be followed; and easy methods of converting longitude into time shall also be given, which will greatly facilitate their application. Other rules shall likewise be given, for converting time into degrees of longitude, or parts of the equator. This last operation is as useful as the first, and is often put in practice.

Method of reducing Degrees of Longitude into Time.

11. When the number of degrees exceeds 100, make use of the tables calculated for that purpose.*

Reduce 133° 17′ 30″ of longitude into time.

Take successively

For 133°	- - - - -	8h 52′ 0″
For 0 17′	- - -	0 1 8
For 0 0 30″	- - -	0 0 2
	Sum -	8h 53′ 10″

This sum is the time required.

12. When the number of degrees is less than 100, it is more convenient to make use of the following rule:

Multiply the seconds, minutes, and degrees, by four, and reckon the seconds of the product for thirds, the minutes seconds, and the degrees for minutes.

Let it be required to reduce into time	43° 17′ 33″
Multiplying by -	4
Product -	2h 53′ 10″ 12‴

* This, however, may be readily done by the rule given in art. 12; and the use of the tables altogether avoided. *Trans.*

Divide the thirds by 6, and it will give a decimal fraction of a second, which, in the present case, is 0″·2; the time will therefore be 2ʰ 53′ 10″·2.*

Method of reducing Time into Degrees of Longitude.

13. This reduction may be made by the assistance of the proper tables.

Let it be required to reduce into degrees 5ʰ 53′ 3″
Take successively

For 5ʰ - - -	75°	0′	0″
For 0 53′ - - -	13	15	0
For 0 0 3 - -	0	0	45
Sum - -	88°	15′	45″

This sum is the required reduction.

When the proposed number contains tenths of a second, multiply the tenths by 6, and the product will be thirds, with which the corresponding parts of the degree is to be sought.

If it were necessary to reduce into degrees 3ʰ 21′ 11″ ·7

Take for 3ʰ - - - - -	45°	0′	0″
for 0 21′ - - -	5	15	0
for 0 0 11″ - - -	0	2	45
for 0 0 $0{\cdot}7\times6=42'''$ -	8	0	10·5
Reduction required, Sum -	50°	17′	55″·5

14. In the case where the proposed number contains only minutes and seconds, it will be most expeditious to follow the reverse of the second method which has been given for reducing degrees into time: viz.

* For practical examples of this and the subsequent rules, see the APPENDIX, by the TRANSLATOR.

Divide the minutes and seconds by four, and reckon the minutes in the quotient as degrees, and the seconds as minutes. *

Reduce into degrees of longitude - -	59′ 44″
The fourth is - - - - -	14° 56′

If the proposed number contain tenths of a second, convert them into thirds, by multiplying them by 6; and reckon the fourth of the thirds for seconds.

Let it be required to reduce into degrees of longitude - - - - -	45′ 35″·4
Write - - - - - -	45′ 35″ 24‴
The fourth of which is - - - -	11° 23′ 51″

Method of calculating the given Quantities that are found in the Nautical Almanac, or the Connaissance des Tems, for any proposed instant.

15. When the quantities contained in the Nautical Almanac, or Connaissance des Tems, change slowly, they are

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* The most expeditious method of converting time into longitude, and which is applicable to all cases, is to divide the minutes, seconds, &c. by four, as above directed, and then to add the product arising from multiplying 15 by the number of hours in the given time, to the degrees in the quotient. By this method, the whole calculation may generally be performed in less time than the several parts of the given quantity can be taken separately from a table; besides the great advantage of not requiring any table. Thus, if it were required to find the longitude answering to 9h. 24′ 55″·4 of time:

First, ·4″ × 6 = 24‴

Then dividing by 4) 24° 30″ 24‴

Quotient - - 6° 13′ 51″

15 × 9 = 135

Longitude required 141° 13′ 51″

It should be remarked, that as the multiplier for converting the decimals of a second into thirds is 6, and the number of hours in the given time, in almost all practical cases, does not exceed 12, these multiplications may always be performed mentally, which will greatly facilitate the whole operation.

calculated for every twenty-four hours; those which change more rapidly, are calculated for every twelve hours: the declination of the moon, given in the Connaissance, is calculated for every six hours.* It would be useless to give a particular example for each of the quantities necessary to be obtained, because all the operations are the same, and are comprehended in the following rules. It will, therefore, be sufficient to unite, in several examples, the principal difficulties that occur in practice.

16. Calculate, according to the rules given in articles 8 and 9, the time at the first meridian corresponding to the proposed instant, or the time of observation: then, take in the Nautical Almanac the declination, right ascension, or any other element corresponding to the nearest epoch preceding that instant, also take the same element corresponding to the next following epoch. The difference of the two quantities thus found will be the change which the declination, right ascension, or other element, has experienced in the interval between the two epochs for which this element has been calculated. Subtract the time of the first epoch from the time at the first meridian, which will give a second interval; then find, by proportional parts, the change which corresponds to it. If the quantities in the tables are increasing, add the calculated change to the quantity cor-

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* The sun's longitude, right ascension in time, and declination, are given in the Nautical Almanac for every 24 hours, or at noon for every day in the year; and his semi-diameter for every sixth day of the month The moon's right ascension, declination, semi-diameter, and horizontal parallax, are also given for every 12 hours, or at both noon and midnight, with the time of her passage over the meridian at the Royal Observatory, Greenwich, for every day, are also given in the same Ephemeris. The latitudes and longitudes of nine of the principal fixed stars are likewise given in the last page of the Nautical Almanac for every year; the longitude for the beginning and the latitude for the middle of the year; with the annual increase of the former, and the variation of the latter. *Trans.*

responding to the first epoch; but if they are diminishing, subtract it from the quantity corresponding to the same epoch.

EXAMPLE I.

On the 15th of March 1810, being in 51° 12' east longitude, required the declination of the sun, at the time of his passing the meridian.

Reduce, by the rules of article 12, the longitude into time, which will give $3^h\ 24'\ 52^s$, or by taking the nearest minute, $3^h\ 25'$. The first meridian is west of that of observation, and it is not yet noon there; hence, subtract $3^h\ 25'$, or the difference of longitude, from the time at the first meridian, which is 0 or 24 hours. The remainder, $20^h\ 35'$, is the time for which the declination of the sun is to be calculated. But the 15th of March has not yet commenced at the first meridian; the calculation must, therefore, be made for the 14th, at $20^h\ 35'$. The nearest preceding epoch is that of the 14th at noon, and the next following one is that of the 15th, at the same hour.

The 14th March at noon, declination	2° 40′ 10″ S.
The 15th - - - - -	2 16 32 S.
Change in 24 hours, difference -	23′ 38″

24^h	23′ 38″	For 12^h - - -	11′ 49″
12	11 49	For 6 - - -	5 54·5
6	5 54·5	For 1 - - -	0 59
3	2 57·2	For 1 - -	0 59
1	0 59	For 0 35′ - -	0 34·4
		For 20^h 35′ Sum -	20′ 15″·9

Make a small table, similar to that on the left hand above, in the following manner: — say, the half of 24^h is 12^h; the half of the change in 24^h is 11′ 49″, which answers to 12^h. The half of 12^h is 6^h, and that of 11′ 49″, or 5′ 54″·5 is the change in 6^h. By following the same method, we shall have

the change in 3^h, which is $2' 57''\cdot 2$. The change for one hour will be the third of this number. It may be seen from the above table, what quantities it is necessary to add together to obtain the change of declination which answers to $20^h 35'$; it is $20' 16''$ nearly, which ought to be subtracted from the declination corresponding to the first epoch, or from $2° 40' 10''$, because the declination of the sun is decreasing, and we shall have the declination required.

The 14th of March at noon	- -	$2° 40' 10''$ S.
Change in $20^h 35'$	- - - - -	$0\ 20\ 16$
Declination 14th March at $20^h 35'$, diff.		$2° 19' 54''$ S.

If the declinations taken from the Nautical Almanac have not the same denomination, that is, if one is north and the other south, it will be a proof that the sun has passed the equator between the two epochs to which the declinations correspond. Then the change in declination in 24^h, instead of being equal to the difference of the two declinations, will be equal to their sum. The following example will show the manner of proceeding under this circumstance.

Example II.

On the 21st of March 1810, at $7^h 12'$ in the morning, civil time, or the 20th March, at $19^h 12'$, astronomical time, being in $41° 22'$ of west longitude, it is required to calculate the declination of the sun at that moment.

The longitude reduced into time is $2^h 45'$, neglecting the seconds: the first meridian is east of the place of observation, and, at the former, it is more than $19^h 12'$; therefore, if to this hour there be added the difference of longitude of the meridians, $21^h 57'$ will be obtained for the time at the first meridian.

Declination ☉, 20th March, at noon	-	$0° 18' 8''$ S.
Declination 21st March, at noon	-	$0\ 5\ 33$ N.
Change in 24 hours - -	Sum	$0° 23' 41''$

24^h	23′ 41″	For 12^h - -	11′ 50″.5
12	11 50.5	For 6 - -	5 55.2
6	5 55.2	For 3 - -	2 57.6
3	2 57.6	For 0 57′ - -	0 56.2
1	0 59.2	For 21^h 57′ -	Sum 21′ 39″.5

From the 20th of March at noon to the 21st at the same hour, the declination at first diminished progressively, until it became nothing, then it changed its denomination, and increased until it became equal to 0° 5′ 33″ N., which is that of the second epoch. Since the change which has taken place between the 20th of March at noon, and the required instant, is greater than the declination at the first epoch, it is a proof that, at that instant, the sun had crossed the equator, and the declination had changed its name. In this case, subtract the declination of the 20th of March, from the calculated change in declination, which will have a different denomination from that of the first epoch.

Declination on the 20th of March, at noon	0° 18′ 8″ S.
Change in declination for 21^h 57′ -	0 21 39
DECLIN. ☉ 20th of March, at 21^h 57′ -	0° 3′ 31″ N.

If the change in the calculated declination had been less than that of the first epoch, the sun would not then have been in the northern hemisphere; therefore, the change in declination must have been subtracted from declination of the first epoch, and the remainder would have been the declination required, of the same denomination as that of the first epoch.

EXAMPLE III.

On the 10th of April 1810, being in 161° 31′ east longitude, required the declination of the moon at 15 minutes past 8 at night, civil time, or 8^h 15′ astronomical time.

The hour at the place is $8^h\ 15'$, or, by adding 24 hours, it is $32^h\ 15'$: subtract $10^h\ 46'$ from this, which is the longitude reduced into time, and the hour at the first meridian will be $21^h\ 29'$; but as it was necessary to add 24^h to the proposed time, the 10th of April had not then commenced at the first meridian, the required epoch is the 9th of April, at $21^h\ 29'$.

Declin. of the ☾ the 9th of April, at 18^h	$18°\ 19'$ N.
Declin. of the ☾ on the 10th of April, at noon	$18\ \ 12$
Change in 6^h :—Difference - - - -	$7'$

		18^h	
6^h	$7'$	For 3 - - - -	$0°\ 3'·5$
3	$3·5$	$0\ ·29'$ - - -	$0\ \ 0·6$
1	$1·2$	For $21^h\ 29'$ - - -	$0°\ 4'·1$

Declin. of the ☾ the 9th of April, at 18^h	$18°\ 19'$ N.
Declination diminishes, *subtract* - - -	4
DECLINATION, the 9th of April, at $21^h\ 29'$	$18°\ 15'$ N.

EXAMPLE IV.

On the 13th of March, at $4^h\ 30'$ at night, being in $91°\ 49'$ of west longitude, required the moon's right ascension.

The longitude reduced into time, is $6^h\ 7'$; this is to be added to the hour at the place, and the time proposed at the first meridian, is the 13th of March, at $10^h\ 37'$.

Moon's right ascension, the 13th at noon -	$16^h\ 12'$
Right ascension, the 13th at midnight -	$94\ \ 27$
Change in 12 hours :—Difference - - -	$8°\ 15'$

12^h	$8°\ 15'$	For 6^h - - - -	$4°\ \ 7'·5$
6^h	$4°\ \ 7'·5$	3 - - - -	$2\ \ 3·7$
3	$2\ \ 3·7$	1 - - - -	$0\ 41·2$
1	$0\ 41·2$	$0\ \ 37'$ - - -	$0\ 25·4$
		For $10^h\ 37'$ - -	$7°\ 17'·8$

Right ascen. of the ☾, the 13th at noon - - -	86° 12′
Right ascension increasing, *add* - - -	7 18
RIGHT ASCENSION required - - - -	93° 30′

The declination and right ascension of the moon are given in the Nautical Almanac only in degrees and minutes. It will be sufficient, in calculating the proportional parts, to take into the account tenths of minutes, and to employ the sum without the fractions. Below 0·5 the tenths are to be neglected; and above that quantity, as in the last case, one minute more is to be taken.

The preceding examples are sufficient to show the method of calculating the quantities that serve to fix the positions which the sun, moon and planets occupy in the heavens. The other elements which experience changes may also be calculated by methods altogether analogous to these, as the mean time at true moon, the semidiameters of the sun and moon, and the moon's parallax.* The time of the moon's culminating, for any other place than those on the first meridian, may also be calculated in the same manner.

17. In the calculations of Nautical Astronomy, it may be supposed that the stars have not any apparent motion, and that they always preserve the same position with respect to each other; or, that their respective distances remain the same. It will, therefore, not be necessary to have any regard to the small periodic changes, denominated nutation and aberration, which amount only to a few seconds. But an attention to the annual variation of the stars in right ascension and declination is indispensable. These last changes do not arise from their proper motion, but from another cause, which shall be explained. It should be recollected, that, in article 6, right ascension has been defined to be an arc of the equator comprised between the circle of declination

* For examples of these calculations, see the Appendix. *Trans.*

of any star, and the point of the ecliptic, where it cuts the equator, and the sun commences his revolution. This point, which is called the vernal equinoctial point, has a very slow retrograde motion, by which it is removed from east to west, or in a contrary direction to that in which right ascension is estimated: this last ought therefore to be progressively augmented by a certain quantity; consequently, the annual variation is always additive. The motion of the equinoctial point appears to be made on the ecliptic; but it really arises from a motion of the earth's axis, by which the plane of the equator, which preserves nearly the same degree of inclination to that of the ecliptic, and has the same motion as the axis, is slightly displaced with respect to the stars; and this always takes place in the same direction: the plane of the equator, therefore, approaches certain stars while it removes from others. The declination of some of the stars ought, on this account, to increase, and their annual variation in declination to be additive; while the annual variation in the declination of those stars, to which the plane of the equator approaches, is subtractive. In catalogues of stars, their right ascensions and declinations are generally given for an epoch but little distant from the time of their publication; the annual variations are found in the column which immediately follows that containing these quantities. These variations in right ascension are always aditive, as already stated, for any periods of time posterior to those in the catalogue, and subtractive for the periods anterior to them. The annual variations in declinations, which are additive for the epochs posterior to those in the catalogues, are preceded by the sign +, and those which are subtractive, by the sign —. Whenever the declination of a star is calculated for any epoch anterior to that of the catalogue which is used, the annual variation must be em ployed with a contrary sign

18. When it is required to calculate the right ascension of a star for any period posterior to that of the catalogue, * multiply the annual variation by the number of years since the time for which the catalogue was calculated.

The proportional parts for the months and days may then be found in the following manner:—Reduce the days into decimals of a month, by dividing them by thirty, and multiply the twelfth part of the annual variation by the number of months and decimal parts thus found. The sum of this product, and the right ascension for the years, is the quantity to be added to the right ascension of the catalogue, in order to obtain the right ascension corresponding to the time proposed.

The same method of operation must be used for finding the declination, with this difference, that the sum for the years and months must be added to the declination of the catalogue, when that declination is preceded by the sign +, but subtracted when it is preceded by the sign —.

Example.

Required the right ascension and declination of *Antares*, for the 16th of April 1808.

Right ascension, Jan. 1st 1805 -		244° 22′ 6″
Declination, Jan. 1st 1805 - -		25 59 0 S.
Annual variation in right ascension - -		54″·6
From the 1st of Jan. 1805 to Jan. 1st 1808		3 years
Product. Proportional parts for the years		2′ 43″·8
Annual variation - -	54″·6	
Twelfth part - - -	4″·5	
The 16th April - -	3 ·5	
	13″·5	
	2 ·3	
Proportional parts for the months	15″·8	

* See Table XVI, at the end of this volume. *Trans.*

Proportional parts for the years - -		2′ 43″·8
Proportional parts for the months - -		15·8
	Sum -	3′ 0″
Right ascension of the catalogue -		244° 22′ 6
RIGHT ASCENSION required -		244° 25′ 6″
Annual variation in declination - -		+ 8″·8
From Jan. 1st 1805 to Jan 1st 1808 -		3 years.
Product. Proportional parts for the years -		+ 26″·4
Annual variation -	+ 8″·8	
Twelfth part - -	+ 0″·7	
The 16th of April - -	3·5	
	2·1	
	0·4	
Proportional part for the months	2″·5 -	+ 2 5
	Sum -	28″·9
Declination of the catalogue - -		25° 59′ 0 S.
DECLINATION required - -		25° 59′ 29″ S.

CHAPTER II.

Corrections which ought to be made in all the observed Altitudes of the Sun, Moon, and Stars.

19. Observed altitudes should be subjected to several corrections before they are employed in calculations. They must first be corrected for the depression of the horizon, and by subtracting or adding the semi-diameter according as the upper or lower limb of the sun and moon has been observed; then they must be corrected for the effects produced by refraction and parallax. The observed altitudes of the sun and moon should almost always be subjected to these corrections. The stars having neither diameter nor parallax, their observed altitudes should only be corrected for the depression of the horizon, and the effect of refraction. The principal causes which render these corrections necessary shall be explained, and the methods of making them shown.

On the Depression of the Horizon.

20. The altitudes observed at sea are arcs of the vertical circles comprised between the heavenly bodies and the visual horizon. They would be the same as the true altitudes, abstracting the other quantities above mentioned, if the visual rays directed to the circle that terminates the visible part of the sea's surface coincided with the

horizontal plane; then they would not require any correction. But these rays are inclined below the horizontal plane, and form an angle with it, called the depression of the horizon, which increases as the observer is more elevated above the surface of the sea.* All observed altitudes are, therefore, too great, and the depression of the horizon must be subtracted from them. This depression is contained in Table I, at the end of this volume for different heights, from one to 100 feet. The height of the observer's eye above the surface of the sea is expressed in feet, and the corresponding depression of the horizon is inserted in the adjoining column on the right hand, and the differences in the next column. When the height of the eye falls between two of the consecutive numbers in the first column, the depression for the proportional parts may be calculated in the following manner:—

EXAMPLE.

Required the depression of the horizon, when the eye of the observer is elevated 15·7 feet above the surface of the sea.

Difference between 15 and 16 feet, in the Table - - - - - - -	7″
Depression for 15 feet - - - - -	3′ 48″
Depression for the proportional parts, 0·7 feet -	5
DEPRESSION for 15·7 feet - - - -	3′ 53″

21. The visual rays which meet the horizon of the sea are tangents drawn from the eye of the observer to the surface of the earth; but, the points of contact of these tangents are more distant, as the eye is more elevated: the visual horizon will, therefore, be as much more distant from

* For the proof of this, and the method of calculating the quantity of the depression, see the Introduction to Table I. of this volume. *Trans.*

the observer, as his height is greater. If an observation be made from the most elevated part of the dead works of a large ship, its distance would be between five and six miles, or nearly two marine leagues. Thus, in navigating near the land, it may happen that the shore is nearer the vessel than the circle which terminates the horizon ought to be; and this is what mariners express, when they say the horizon is bounded by the land. Then the visual rays that meet the shore are more inclined below the horizontal plane than those by which the horizon would have been perceived; the depressions of Table I, are then too small, and only a part of the corrections can be applied to the altitudes. The fourth column contains the distances corresponding to the different heights. When the estimated distance from the shore is either greater than or equal to the distance in the Table, which answers to the height of the eye, the depression which is found in the same Table may be employed for correcting the altitude. It is essential to remark, that an error of a mile, committed in estimating the distance of the shore, ought not generally to occasion an error in the altitude of more than a quarter of a minute, and never more than a minute. When the depression of the horizon is affected by an error of this kind, the corrected altitude will always be too great. If the distance taken from the Table exceed the estimated distance between the observer and the shore by more than a mile, it will be a proof that the horizon is bounded by the land: then the depression of Table I, cannot be employed for correcting the altitude. It would be useful to ascertain this some time before the observation is to be made, in order to preserve a convenient distance from the shore. In general, when the elevation of the eye does not much exceed 26 feet, there is not any fear of committing an error of more than a minute, at least at a league or three miles from the land.

22. Several much esteemed works on navigation contain methods of ascertaining directly from observation, the inclination of the visual ray that meets the shore by which the horizon is bounded. The directions there given are to observe, at the same instant, the altitudes of the sun, from two places situated exactly in the same vertical line, but of very different elevations. But the methods of calculating the corrections are either long and troublesome, or only approximations, by which sufficient accuracy is not obtained. It would not be difficult, however, to give great precision to the approximating methods, by means of a small table which would not add much to the length of the calculations; nevertheless it has been suppressed, because the methods that are here given for avoiding the errors in the depression of the horizon, are not only sufficiently accurate, but much more convenient in practice. When altitudes are to be obtained with all the accuracy of which these observations are susceptible, it will always be best to remove from the land, and to preserve the distance indicated in the first Table.

23. The depressions in this Table have been calculated from the dimensions of the terrestrial globe *, concluded from the new measure of an arc of the meridian, taken for the purpose of fixing the length of the metre. To correct them for the effects of refraction, which generally increases the apparent elevations of objects, they have been diminished by $\frac{8}{100}$ths, a quantity or co-efficient which Delambre has found by numerous observations, and which has since been

* The mean radius of the earth, or that of 45°, considering it as an illipsoid, employed in these calculations, is therefore equal to 3,266,611 toises, 6,366,745 metres, 6,964,837 English yards, or 3957·3 miles nearly; the French metre being equal to 1·09 394 Eng. yards. *Trans.*

confirmed by M M. Biot and Arago, by observations made in Spain, for extending the measure of the meridian.

24. The variations which common refractions cause in the depressions of the horizon, are so small, that they may be neglected in the practice of navigation. We shall, therefore, content ourselves with mentioning, in this place, some extraordinary phenomena which M. Biot has proved by the most delicate observations, and of which he has given the first satisfactory explanation, by subjecting them to the most rigorous calculations of analysis. The limits within which it is necessary to comprise this treatise, do not permit us to follow his learned researches; we shall, therefore, only extract the most useful results. Their importance cannot fail of being felt by mariners, to whom they will afford new means of perfecting their art.

The great errors which refraction may occasion in the depression of the horizon, arise from the difference which almost always subsists between the temperature of the water at the surface of the sea, and that of the air at several yards above it. Experience has shown, that the region where these errors are the most sensible, is from the surface of the water to 10 or 11 yards in height. Therefore the visual rays from the eye of an observer on the deck of a vessel, by which the altitudes of the heavenly bodies are referred to the horizon, always traverse this region; and it is important to know the circumstances under which the greatest errors take place, in order to guard against those by which the observations ought then to be affected. These errors are subject to frequent variations, occasioned by the changes which the rays of the sun suddenly effect in the temperature of the atmosphere, either when he emerges from behind a cloud, or becomes hidden by one. It is probable that we shall never obtain an exact knowledge of their value; or at least, very minute attentions would be requisite to obtain it; and

if it were known, it might not be of great use in Nautical Astronomy; we shall therefore rest satisfied with giving an approximative value of these errors, and showing in what manner they ought to affect the altitudes: attention shall also be paid to give such indications only as are easy to be comprehended, and may be understood by all.

25. The causes which give rise to the variations in the extraordinary refractions of the visual horizon are the same that produce those phenomena which the French mariners call Mirage, and the English, Looming; thus, whenever the phenomena of looming are manifest, the depression of the horizon will be very uncertain during their whole continuance.

The direction in which the errors in the depression of the horizon, and consequently, those of the observed altitudes, take place, depend upon the temperature of the sea being greater or less than that of the incumbent atmosphere.

1st. If the sea be warmer than the air, the altitude corrected by the depression taken in the Table will be too great.

2nd. If the sea be colder than the air, the corrected altitude will be too little.

3rd. When the temperature of the sea is from 7° to 10° of Fahrenheit's thermometer, different from that of the air at the height of one or two yards above the surface, the error in the altitudes may be from 3′ to 4′; a difference of from 4° to 6° of temperature may occasion an error of 1′ or 2′.

4th. The water of the sea is heated much more slowly by the presence of the sun than the atmosphere, it will therefore be colder than the air for some time after the rising of that luminary; then the altitudes corrected by the depressions in the Table will be too little, and will continue to be so, all other things remaining the same, until the heat of the

day is considerably augmented. In the evening, the contrary takes place; the altitudes corrected for depression will begin to be too great as the heat of the day diminishes, and their errors will continue to increase until the sun has set. The depressions in the Table are corrected for the effects of common refraction; thus, whenever extraordinary refractions depress the horizon, instead of elevating it, the altitudes will be too great; and this is the reason why they should be a little more at night than in the morning.

Those accidental and extraordinary refractions may serve to explain, why certain latitudes observed at sea by navigators, equally careful and experienced, sometimes differ several minutes from each other, while in general, their observations are found to agree.

On the Semi-diameters of the Sun and Moon.

26. The altitudes of the upper or lower limbs of the sun and moon only can be obtained immediately from observation; the semi-diameters of these bodies must therefore be added to, or subtracted from these observed altitudes, in order to obtain those of their centres. These semi-diameters are not the same at all times of the year or month, but it will be easy to calculate them, from the *Nautical Almanac* or the *Connaissance des Tems*, for any proposed instant.

27. When the lower limb of the sun or moon has been observed, the semi-diameter must be added to the observed altitude; but if the upper limb, it must, on the contrary, be subtracted.

When the supplement of the sun's altitude is observed, by bringing that edge of his image into contact with the horizon, which appears to be nearest it, but which is effectively the most distant, the semi-diameter must be subtracted from the supplement of the altitude which has been observed.

Several examples of these operations will be subsequently given, which are so simple, that it has been thought proper to dispense with them here.

28. The semi-diameter of the moon appears to be increased by a small quantity as she becomes more elevated. There will be found in Table II, entitled, *Augmentation of the Moon's Semi-diameter*, the quantity that must be added to the true or horizontal semi-diameter, in order to obtain that which agrees with the observed altitude. Thus, when the apparent altitude of the moon's centre is to be calculated, the semi-diameter corrected for this augmentation, or the apparent semi-diameter, is to be employed.

Astronomical Refraction.

29. Astronomical refraction is the quantity by which the heavenly bodies, after their luminous rays have traversed the atmosphere, appear to be more elevated than they really are. It ought always to be subtracted from the observed altitudes. The greatest refraction takes place when the bodies are in the horizon; it diminishes as their altitudes increase; and becomes nothing when they have arrived at the zenith.

30. Refraction is not always the same at the same altitudes; it varies on account of the greater or less density of the atmosphere. In general, the more dense the atmosphere is, the greater is the astronomical refraction; it also diminishes as the density of the air decreases. Cold has the property of condensing the air, and heat of rarifying it; the density of the air is, therefore, increased by cold, and diminished by heat. It follows from this, that the variation in the height of the mercury in the thermometer may be employed in calculating the corresponding changes which the astronomical refractions ought to experience. The atmo-

sphere is also more dense when its weight is greater, or when it sustains a longer column of mercury in the barometer; and a less elevation of that column indicates a diminution in the density of the atmosphere. The changes of atmospherical refraction depend, therefore, upon the height of the mercury in the barometer. These refractions will be greater as the column of mercury is more elevated, and less as the height of the column is diminished.

31. The numbers in the third column of Table V, intituled, *Refraction of the* ✱, or of the stars, are the refractions of all the heavenly bodies; but, for reasons that shall be explained, they are to be used only in correcting the altitudes of the stars. These refractions have been extracted from the Tables published by the French Board of Longitude, and reduced to those that take place when the mercury, in the centigrade thermometer, stands at 14° above zero, or, in Fahrenheit's thermometer, at 57°·2; and the height of the mercury in the barometer is ·76 of a metre, or 29·92 English inches.

The numbers in the second column, entitled, *Refraction less Parallax of* ☉, or of the sun, are those of the third column, from which the parallax of the sun, agreeing with the altitudes opposite the corresponding numbers, has been subtracted. They are only to be used for correcting the altitudes of the sun; with respect to the altitudes of the moon the numbers in Table VIII, which are the refractions of the moon diminished by her parallax, should be employed. When the calculations do not require a very great degree of precision, the numbers in Tables V, and VIII, may be used without any regard to the variations experienced by the refractions in consequence of the changes in either the temperature or weight of the atmosphere.

32. But when it is required to correct the apparent distance between the moon and the sun or a star, the cor-

rections corresponding to the heights of the mercury in the barometer and the thermometer must be applied to the numbers of the Tables V, and VIII. These corrections are to be found in Tables VI, and VII, the use of which shall be shown by an example.

Example.

The apparent altitude of the sun's centre being 17° 45′, Fahrenheit's thermometer 82°·4, and the barometer 29·53 inches nearly, required the refraction diminished by the parallax.

In the second column of Table V, we find, at 7° 40′ of altitude, that the refraction diminished by the parallax is 6′ 35″. The column of *Differences*, which is common to the refractions of the stars and those of the sun, shews that the refraction diminishes 8″ for an increase of 10′ in altitude; for 5′, it will therefore decrease 4″; and the calculation is to be performed in the following manner:—

Apparent altitude ☉	7° 40′,	refraction - -	6′ 35″
Proportional parts for	- 5′,	*subtract*, - - - - -	4
Apparent altitude ☉	7° 45′,	refraction - - -	6′ 31″
Thermometer - -	82°·4	Table VI, *Subtract*	21
Apparent altitude ☉	7° 45′		
			6′ 10″
Barometer 29·53 - - - -		Table VII, *Subtract*	5
Apparent altitude ☉	7° 45′		
Corrected Refraction		- - - - - - - - -	6′ 5″

Parallax.

33. The positions of all the heavenly bodies is given in the Nautical Almanac, or Connaissance des Tems, relatively to an observer supposed to be situated at the centre of the earth; this is, therefore, the point to which all the lines employed in measuring angular distances should be

referred. The altitude of any heavenly body observed at the surface of the globe, can only be equal to that which would have been observed at the centre, when the heavenly body is very distant, and when the distance of the two places of observation, or the radius of the earth, may be regarded as comparatively nothing with respect to the distance of that body. In fact, the line supposed to be drawn from that point of the earth's surface, where the observation is made to the heavenly body, would then be parallel to that supposed to be drawn from the centre of the earth to the same body; or, at least, the angle which these lines would form would be so small, that it might be considered as nothing. This is what takes place in observations of the stars, the distances of which from the earth are very great; their positions as determined by an observer placed at the surface of the globe, are the same as would have been observed at the centre of the same sphere: consequently, the stars have not any parallax. But when the altitudes of the moon, which is the nearest of all the heavenly bodies, are observed, the line supposed to be drawn from the point of the earth's surface where the observation is made, to the moon, will make an angle with that supposed to be drawn from the centre of the earth to the same heavenly body: then the altitude observed at the surface will not be equal to that which would have been measured at the centre. The difference of these two altitudes is, what is called Parallax of Altitude.

It ought to be remarked, that the vertical line is the prolongation of the radius of the earth, considered as spherical, through the point where the observation is made; consequently, whenever the moon is in the zenith, the two lines supposed to be drawn to her, the one from the centre, the other from the point of observation, will form only one: then the parallax is nothing. When the moon begins to

depart from this vertical line, her altitude decreases, and the two lines form an angle between them, which increases in proportion as the altitude diminishes. Finally, when the moon has arrived at the horizon, the line supposed to be drawn from the eye of the observer to that body is perpendicular to the radius of the earth, which joins the centre and the place of observation; and the parallax ought therefore to have its greatest value: hence this value depends upon the apparent altitude. Since the place of observation, and the centre of the earth, are always in the same vertical line, it is evident that the observer is always situated at a greater elevation than the centre; hence the height of the moon will appear to him to be too little: the parallax ought, therefore, to be added to the observed altitudes.

The greatest parallax takes place when the altitude is equal to nothing, and is called the Horizontal Parallax; it is that which is given in Astronomical Tables, and in the Nautical Almanac, or Connaissance des Tems. Its value varies rapidly; it frequently increases to 60′ and some seconds; then it diminishes to less than 54′. It is usually calculated for every 12 hours. That which corresponds to any proposed instant may be found by rules analogous to those which have been given for obtaining the different elements relative to the positions of the heavenly bodies.

34. When the sun is above the horizon, his parallax of altitude varies according to the same laws as that of the moon; but his horizontal parallax is much less, and experiences only very small changes. It is never more than 8″·95, nor less than 8″·65. It is therefore supposed to be constantly equal to 8″·8; and the value which it ought to have at different altitudes have been subtracted from the corresponding refractions at those altitudes; by which means the numbers in the second column of Table V, entitled.

Refraction diminished by the Parallax of ☉ have been obtained. They give the correction of the sun's altitude, for refraction and parallax at once.

35. It is evident, from what has been said above, that the moon's parallax ought to be greater, as the place of observation is more distant from the centre of the earth; and that it should be the same at all places equally distant from this centre. If the earth were spherical, the horizontal parallax would be the same in all places; but as its form is that of a spheroid slightly compressed at the poles, the equatorial radii are the greatest, and its radii decrease successively in approaching the poles: the parallax ought, therefore, to diminish at the same time, in a very small degree. When the parallax is taken from the Connaissance des Tems, it is that which takes place at the equator; and, to obtain that which corresponds to the latitude of the place of observation, it must be subjected to a slight correction. Before calculating the parallax of altitude, we should search in Table III, entitled, *Diminution of the Equatorial Parallax*, for the quantity which is to be subtracted from the parallax given in the Ephemeris.

36. The numbers in Table VIII, are the parallaxes of the moon diminished by refraction, for every 10′ of altitude, and for every minute of the horizontal parallax. The proportional parts for the seconds of the parallax are found in the continuation of the table. When the altitude of the moon is below 10°, the proportional parts for the minutes of altitude must be calculated by means of the difference of the numbers corresponding to the two heights, between which the observed altitude is found. Above 10°, the proportional parts are immediately found in the last column of the table.

37. When the apparent distance of the moon from the sun or a star is to be corrected, the numbers in Table VIII,

must be increased or diminished, by the value of the corrections which ought to be made in the refractions on account of the temperature and weight of the atmosphere. It is essential to remark, that in this case, the numbers ought to be employed in a contrary sense to that denoted at the head of the Tables VI. and VII; in fact, the numbers of Table VIII, being the parallax of the moon diminished by refraction, the greater the refraction is, the more the number in the table is to be diminished: an increase of refraction therefore diminishes them; and, for the same reason, a decrease of refraction increases them.

EXAMPLE.

On the 23d of April 1810, at 21′ past 1 in the morning, civil time, or the 21st, at 13ʰ 21′, astronomical time, being at 43° 36′ of north latitude, and 31° 7′ of east longitude, the altitude of the moon's centre, corrected for the depression of the horizon, was 23° 44′. Required its true altitude.

The hour at the first meridian corresponding to the proposed hour is the 21st at 11ʰ 17′

Horizontal parall. at the equator	21st at noon	59′ 21″
	21st at midnight	59 29
Change in 12 hours - - - - - -		8″

12ʰ	8″	For 6 hours - - - - -	4″
6	4″	3 - - - - - -	2
3	2	1 - - - - - -	0·6
1	0·6	1 - - - - - .	0·6
		0 17′ - - - - -	0·2
		11ʰ 17′ - - - - -	7″·4

Horizontal parall. at the equator, 21st at noon	59′ 21″
Proportional parts for 11ʰ 17′ - - - -	7
Sum	59′ 28″
Diminution of the equatorial parallax - -	6
Horizontal parallax for the latitude - -	59′ 22′

Refraction — parall. of the ☾ for 23° 40'	-	51' 53"
for 4' of altitude	-	— 1
for 22" of hor. parallax	-	+ 20
Parallax of altitude — refraction	-	52 12
Apparent height of ☾'s centre	-	23° 44' 0
True altitude of the ☾	-	24° 36' 12"

Correction of the Less of Two Altitudes taken out of the Meridian, for obtaining the Latitude.

38. The method given in this Treatise for calculating the latitude from two altitudes of the sun, taken out of the meridian, and the interval of time elapsed between the observations, requires these observations to be made at the same place; but, as it almost always happens, that the altitudes are taken in two different places, it becomes necessary to correct one of these data of the calculations, in order to obtain that which would have been found if both the observations had been made at the same point of the globe. These corrections depend upon the direction and length of the ship's course during the interval between the observations. The difference of latitude and longitude answering to the length and direction of the course must first be found by the known means, which will, at the same time, be the difference of latitude and longitude of the two places of observation. It will be easy to have respect to the difference of longitude, as will be subsequently shown. It is only required in this place to take into the account the way made in latitude, in order to correct the less of the two observed altitudes.

The calculation should give the latitude of the place where the greater altitude was observed; and the less altitude is always to be corrected. Tables XII and XIII, afford an easy method of finding this correction; which appears to be

so much the more advantageous, as it renders the uncertain observation of the sun's azimuth unnecessary.

39. The operations necessary for this purpose may be divided into two parts; in the first it is required to find, by means of Tables XII and XIII, a number which is called the multiplier of the difference of latitude; the second part consists in the manner of employing this multiplier in obtaining the correction of the less altitude. The rules which should be followed shall first be explained; and then several examples for facilitating their application given.

40. Search, in one of the left-hand pages of Table XII, with the latitude, which is inserted at the head of each column, and the less altitude, which is contained in the first column of the table, a number which is the first term, and write it down separately; then, with the same data, look in the right-hand page of the same table for the argument, which write opposite the first term.

With the argument thus found and the declination of the sun, according as it is of the same or a different denomination with the latitude, search, in Table XIII, for the second term, and write it below the first.

Subtract the first term from the second, increased by two units if necessary; and the remainder will be the multiplier sought.

This rule holds good in all cases, except that in which the latitude and declination are of the same denomination, and the declination greater than the latitude. Then the second term must be subtracted from the first, and the required multiplier will be obtained. It must be observed, that in this circumstance only, the sun passes the meridian between the observer's zenith and the elevated pole; and then the second term is always less than the first.

41. The less altitude will be corrected by attending to the following rules.

When the meridian altitude ought to be greater in the place of the greater observed altitude than in that of the less, add the difference of latitude to the less altitude; and then subtract the product of this difference of latitude and the multiplier already found from the sum.

If the meridian altitude should be less at the place of the greater observed altitude than at that of the less, subtract the difference of latitude from the less observed altitude; and then add to the remainder the product of the same difference of latitude and the multiplier, found by means of Tables XII and XIII.

To render the application of these rules more easy, it must be observed, that the product of the difference of latitude and the calculated multiplier, should always be employed in a contrary sense to the difference of latitude itself; that is, the product must always be subtracted when the difference of latitude has been added: on the contrary, the product must be added when the less altitude has been diminished by the difference of latitude.

Example I.

Being in estimated north latitude 33° 19′, the altitude of the sun was observed to be 31° 12′. Some hours afterwards, the altitude of the sun was taken again, and found to be 75° 22′. In the interval of these observations, the vessel had sailed 10½ leagues, or 31·5 miles to the S.W. ¼ S. 5° S. The declination of the sun at the instant of the first observation was 20° 41′ N. It was required to determine what would have been the least of these altitudes, if it had been made in the same place as the greater.

The known method of reducing the courses, shows that the difference of longitude of the two places of observation is 18′·1, and the difference of latitude 27′·6, of which the place of the greatest altitude is more to the south than that

of the less. As it is only necessary to make use of the way made in latitude, the last quantity only will be employed.

In the first place, there must be sought in the page of Table XII, which is entitled, *First Term*, the number corresponding to 38° 19′ of latitude, and to 31° 12′ of altitude, and there will be found 1·39, which is to be written down as in the following calculation. Then, in the page entitled, *Argument*, which is on the right of the preceding one, it will be seen that the argument corresponding to the same latitude and altitude, is 1·40, and this is to be written opposite the former number. This argument and the declination, which is of the same denomination as the latitude, serve to find, in Table XIII, the second term, which is 0·50, and which is to be written below the first. As the latitude of the place is of the same denomination, and greater than the declination of the sun, the first term 1·39, is to be subtracted from the second 0·50, increased by two units, or 2·50; the remainder, 1·11, is the required multiplier. The product arising from the difference of latitude of the two places of observation multiplied by 1·11, is 30′·7.

It should be observed, that the latitude being N. as well as the declination, but the former greater than the latter, the sun passes the meridian to the south of the observer. Since the place of the greater altitude is south of that of the less, the meridian altitude of the former ought to be greater; the way made in latitude, which is 27′·6, must therefore be added to the less altitude of the sun, 31° 12′, and we shall have 31° 39′·6, from which there must be subtracted, according to the preceding rules, 30′·7, or the product of the difference of latitude, by the number which has been found by the assistance of Tables XII and XIII; the less altitude reduced to the place of the greater will then be 31° 8′·9, or,

by neglecting the seconds above 50″, 31° 8′ 50″. The operations may be arranged in the following manner:—

Alt. ☉. 31° 12′ Lat. N. 33° 19′	1st term	- 1·39.	Argum. 1·40
Declin. 20′ 41′ Argum. 1·40	2d term	- 2+0.53.	Differ. of lat. 27′·6
	2nd term — 1st term.	1·11	Multiplier 1·11
			27·6
			2·8
			0·3
			Product 30′·7

The sun passes the meridian to the south of the observer, and its meridian altitude ought to be greater in the place of the greatest altitude than in that of the less.

Less altitude of the ☉	- - - - -	31° 12′
Add the difference of latitude	- - - -	27·6
	Sum - -	31° 39′·6
Subtract the product	- - - - - -	30·7
Less altitude reduced to the place of the greater		31° 8′·9
	or -	31° 8′ 50″

As the detail of the operations for finding the less corrected altitude, given in the preceding example, will be sufficient to show the manner to be followed in all other cases, the greater part of this detail is suppressed in the two following examples:—

Example II.

Being in 48° 10′ of N. latitude, the less altitude of the sun was observed to be 12° 26′; some hours afterwards, the greater altitude was found to be 28° 15′. The vessel had sailed 11⅓ leagues, or 34 miles to the N.E. and the declination of the sun was 4° 32′ S

The place of the greater altitude was therefore 24′ north of that of the less.

Alt. of the ☉. 12° 26′	1st term 1·25.	Argum. 1·53.		
Lat. North 48° 10′				
		Diff. of lat.		24′·0
Declin. S. - 4° 32′	2d term 1·89.	Multiplier		0·64
Argument - 1·53				
2nd term — 1st term, Multiplier 0·64				14′·4
				0·9
		Product	-	15′·3

The sun passes the meridian to the south of the observer, and his meridian altitude, at the place of the greater altitude, ought to be less than that at the place of the less.

Less altitude of the sun - - - -	12° 26′
Subtract the difference of latitude - - -	24
Difference -	12° 2′
Add the product - - - - - - - -	15·3
LESS ALT. reduced to the place of the greater	12° 17′·3
or, by taking the nearest tens of seconds	12° 17′ 20″

EXAMPLE III.

Being in S. latitude 8° 42′, the greater altitude of the sun was found to be 70° 31′. After his passage over the meridian, the less altitude was observed to be 50° 22′. The vessel had sailed 4½ leagues, or 13½ miles to N. N. W. in the interval between the observations. The declination of the sun was 22° 30′ S.; consequently, it was of the same denomination with the latitude, but greater.

The place where the greatest altitude was observed was 12′·5 to the south of that where the less was taken.

Alt. of the ☉.	5° 22′	} 1st term 1·06.	Argum. 1·57.	
Lat. South -	3 42			
Declin S. -	22 30	} 2nd term 0·60.	Diff. of lat.	12′·5
Argument	1·57			
		1st term — 2nd term, 0 46.	Multiplier	0·46
				5·0
				0·8
			Product -	5′ 8

The sun crosses the southern part of the meridian; the meridian altitude at the place of the greater altitude should therefore be greater than at the place of the less. Hence, the

Less altitude of the sun - - -	5° 22′
Add the diff of latitude - - -	12·5
Sum -	50° 34′·5
Subtract the product - - - - -	5·8
LESS ALT reduced to the place of the greater	50° 28′·7
or, by taking the nearest tens of seconds	50° 28′ 40″

CHAPTER III.

On the Latitude.

42. THE latitude may be found at sea by three different kinds of observations. The most common and the most simple, is an observation of the meridian altitude; the second consists in observing several altitudes near the meridian, and concluding the meridian altitude from them; this is that by which the greatest degree of accuracy is obtained, but, as the calculation is rather long and requires a knowledge of the time corresponding to each observation, it is *only* necessary to employ it in ascertaining the latitudes of places, the exact positions of which are essential to be known. Lastly, the latitude may be obtained from the observation of two altitudes taken out of the meridian and the interval of time elapsed between them. Though this last method may not be susceptible of giving the latitude with as much precision as the others, it is of great use in the practice of navigation, when the sun is obscured at noon and it is impossible to observe his meridian altitude. The rules proper for each of these methods shall be given.

To find the Latitude by the Meridian Altitude of any of the heavenly Bodies.

43. The latitude may be calculated, as explained in article 5, by adding the meridional zenith distance of a hea-

venly body, of which the altitude has been observed, to its declination; or else by subtracting these quantities from each other. In the following rules, the altitude itself, which is obtained directly by observation, is to be employed. The operations resulting from them differ from those in common use; but the following explanations will make their application more easy.

44. When we are at the terrestrial equator the latitude is nothing; then the celestial equator passes through the zenith, and the two poles are in the horizon. If we advance along the meridian into either hemisphere, the pole of that hemisphere will appear to rise above the horizon by an arc equal to the latitude passed through; and the latitude is equal to the altitude of this pole. The pole of the other hemisphere, on the contrary, descends on the opposite side below the horizon, and the celestial equator is on that side depressed the same number of degrees. The celestial equator is therefore towards the depressed pole, and its inclination to the horizon is equal to the complement of the latitude. From this last principle, the following rules for calculating the latitude directly by means of the meridian altitude are obtained. It is easy to perceive, that the inclination of the equator to the horizon is measured by an arc of the meridian comprised between these two circles; this arc is called the altitude of the equator; but it should be understood, that it is effectively the altitude of that point only of the celestial equator which is cut by the meridian.

45. First, calculate the time at the first meridian corresponding to the instant at which the observed body passes the meridian, and look in the Nautical Almanac for its declination at that time; then correct the observed altitude for the depression of the horizon and refraction: if the altitude of the sun or moon have been taken, regard must be had to semi-diameter and parallax; which last quantity will be

obtained at the same time as the refraction, by taking, if required for the sun, the numbers from the second column of Table V; if for the moon, the numbers must be taken from Table VIII. When the true altitude and declination are obtained, the latitude may be calculated.

1st. Remark towards what pole the heavenly body was, when the meridian altitude was taken; that is, on what side of you it passed the meridian.

2nd. If the declination has a different denomination from that of the pole towards which the altitude was observed, subtract the declination from the true altitude; the remainder will be the altitude of the equator, the complement of which is equal to the latitude. The heavenly body, in this case, has passed the meridian towards the depressed pole, and the latitude will have a denomination different from that of the pole towards which the altitude of the body was observed: this rule is without exception.

3rd. If the declination be of the same denomination as the pole towards which the meridian altitude of the heavenly body was observed, the declination must be added to the true altitude; the sum will be the altitude of the equator. When this sum is less than 90°, the sun has been observed towards the depressed pole, as in the preceding case; and its complement will be the required latitude, the denomination of which is different from that of the depressed pole.

When the sum of the declination and the true altitude, or the altitude of the equator, is greater than 90°, it is a proof that the celestial equator was behind the observer, or on the contrary side of his zenith, at the time the altitude was observed; then the body has passed the meridian towards the elevated pole. Subtract 90° from the sum of the declination and the true altitude, the remainder will be the latitude; the denomination of which ought to be the same as that of the pole towards which the meridian altitude was observed.

EXAMPLE I.—*Altitude of the Sun.*

On the 29th of April 1810, being in 31° 10′ of west longitude, the sun passed the meridian towards the south; the meridian altitude of his lower limb was observed to be 51° 25′; the elevation of the eye above the surface of the sea was 8¾ yards, or 26¼ feet; required the latitude of the place of observation.

By the rules in art. 9, the hour at the first meridian at the time of the observation, is found to be $2^h\ 5'$; this time is therefore the 29th at $2^h\ 5'$; by following the directions given in art. 16, the declination of the sun will be found to be 14° 21′ 57″ N.

Observed altit. of the lower limb of the ☉.		51°	25′	0″
Elevation of the eye 26¼ feet Depression	-		5	1
Remainder	-	51°	19′	59″
Semi-diameter of the sun - - -	-	+	15	54
Sum	-	51°	35′	53″
Refraction—Parallax of the ☉ - -	-	—	0	40
True altit. of the ☉. towards the S.	-	51	35′	13″
Declination of the ☉. towards the N.	-	14	21	57
Altitude of the equator—*Difference*	-	37	13′	16″
Complement. LATITUDE N. - -	-	52	46′	44″

EXAMPLE II.—*Altitude of the Moon.*

On the 26th of March 1810, being in 13° 7′ west longitude, and 25° 36′ of north latitude, the moon passed the meridian towards the south at $4^h\ 20'$ in the morning, or the 25th at $16^h\ 20'$, the meridian altitude of her upper limb was 46° 19′; and the elevation of the eye 23 feet above the level of the sea. Required the latitude.

The time of the moon's passage over the meridian was, at the first meridian, $19^h\ 12'$; when she had 17° 43′ of south declination.

Altitude of the upper limb of the ☾. -		46° 19′ 0″
Elevation of the eye 23 feet - - -		— 4 41
	Remainder -	46° 14′ 19″
½ horiz. diam. 16′ 5″ / Augmentation + 12	Semi-diameter of the ☾	— 16 17
Apparent altitude of the ☾'s centre -		45° 58′ 2″
Horiz. Parallax 58′ 57′ / Diminished 58 55	Parallax—refraction	+ 40 2
True altitude of the moon towards the S.		46 38 4
Declination of the ☾ towards the S. -		17 43 0
Altitude of the equator - -	Sum -	61° 21′ 4″
Complement. LATITUDE N. - -		25° 38′ 56″

EXAMPLE III.—*Altitude of a Star.*

On the 16th of April 1808, Antares passed the meridian towards the south, his observed altitude was 64° 30′, and the elevation of the eye was 21·3 feet.

It has been found, art. 18, that the declination of Antares, on the 16th of April 1808, was 25° 59′ 29″ S.

Observed altitude of Antares towards the S.		64° 30′ 0″
Elevation of the eye 21 3 - -	Depression	— 4 31
	Remainder	64° 25′ 29″
Refraction - - - - - - -		— 28
Altitude of Antares towards the S. -		64° 25′ 1″
South declination - - - -		25 59 29
Altitude of the equator - Sum - -		90 24′ 30″
Subtract 90°. - LATITUDE S. - -		0° 24′ 30″

To find the Latitude by several Altitudes of the Sun, taken very near the Meridian.

46. When we wish to find the latitude from several altitudes taken near the meridian, the greatest possible number of altitudes must be observed in the interval of 14′ or 16′;

the observations are to be commenced 7′ or 8′ before the passage of the sun over the meridian, and continued 7′ or 8′ after that time. Astronomers calculate by a direct and rigorous method, the quantities that must be added to each of the observed altitudes, in order to obtain from it the meridian altitude; but as in the practice of navigation, an error of 2″ or 3″ is of little importance, we shall give a method of approximation which is more generally used, because the calculations are rather more simple. By this method, a number of meridian altitudes, equal to that of the observations, is obtained; and the latitude is reduced from them with much greater precision than could possibly be done from a single observation of the meridian altitude. It is unnecessary, as will shortly appear, to calculate the correction for each observed altitude; it is sufficient to find the correction of the mean altitude which results from all the observations, and, by this means, the calculations are much abridged.

It may be supposed, without apprehending any sensible error, that in the interval of 7′ or 8′ before the passage of the sun over the meridian, and the same time after, the changes in the altitudes are proportional to the squares of the times elapsed before or after this passage. Now, it is possible to calculate the quantity which the sun ought to ascend during the last minute of his approach to the meridian, and the first of his departure from it; it is therefore easy to conclude from this, how much he ought to ascend or descend in any other interval, provided that interval does not exceed 7′ or 8′ minutes. It is only required to multiply the change in altitude which answers to the last minute before his passing the meridian, or the first after it, by the square of the interval corresponding to each observation, or by the square of horary angle. Such is the fundamental principle of this method of approximation. It requires a knowledge of the time of each observation; a seconds watch

must therefore be used, or, what is still better, a marine chronometer, the rate of which shall have been calculated from observations taken in the morning or evening of the same day. The method of finding the time at the place where we are, and of ascertaining the quantity which a watch or chronometer, going either too fast, or too slow, differs from the true time, will subsequently be given; in the following rules, it is supposed that this quantity is known.

47. The corrections of the observed altitudes will be greater or less as the observations have been made farther from or nearer to the meridian, or as the corresponding horary angles are greater or less. If the time of the sun's passage over the meridian, as marked by the watch, is affected with an error, and this error is of such a nature as to increase the horary angles of the observations taken before the sun's passage, it will follow, that the corrections of the corresponding altitudes will be too great. The same error will diminish the horary angles of the observations taken after the passage, and the corrections of these last altitudes will be too small; in the case in which the horary angles of the former observations are too little, those of the latter will be too great. An error in the time by the watch will therefore have an influence, in a contrary sense, upon the corrections of the altitudes observed before and after the passage of the sun over the meridian; and, consequently, upon the meridian altitudes deduced from them. Hence it follows, that if an arithmetical mean of all the calculated meridian altitudes be taken, the errors, in one sense, will either wholly, or in part, compensate for those of the contrary or opposite kind; and the error in the mean altitude, or of the latitude itself, will always be less than the greatest errors above mentioned. It ought, therefore, to be regarded as a general rule, that the same number of altitudes should,

as often as possible, be observed before and after the passage of the sun over the meridian.

48. Calculate, before-hand, within nearly half a minute, the time which the watch ought to give at the instant of noon. Commence the observations 7 or 8 minutes before this instant, and mark the hour, the minute and the second, corresponding to each; cease to observe 7 or 8 minutes after the sun has passed the meridian. If a sextant is used, the arc indicated by the index on the limb of the instrument must be read off at every observation; and its value written down opposite the corresponding time. When the reflecting circle is used, the arc passed over by the index of the great mirror, must be read off at the end of every second or even observation. This method of reckoning will enable the observer to reject those observations which he may judge defective, either from their differing too much from others, or because of some unforeseen accident during the observation itself.

Take the sum of all the altitudes, if they were observed with a sextant, or the whole arc passed over by the index, if the reflecting circle was used, and divide this sum or arc by the number of observations, which will give the mean apparent altitude. Correct this altitude for the depression of the horizon, the diameter of the sun, and the effects of refraction and parallax, and the true mean altitude will be obtained, which is only to be augmented by the quantity found by the following rules, in order to conclude from it both the meridional altitude and the latitude of the place of observation.

1st. It is supposed, that the time the watch ought to give at noon has been calculated from observations made in the morning or evening, and at a place little distant either to the east or west from that where the altitudes near the meridian are to be observed. Correct this time (art. 8. and 9.), by

means of the way made in longitude during the interval between the observations; and the time of the sun's passage over the meridian, at the place where the altitudes are observed, will be obtained.

2nd. Search in Table IX, with the estimated latitude and the declination, for the quantity which the sun ought to ascend or descend in the minute before and after his passage over the meridian. This quantity is expressed in seconds, and fractions of a second; write it down as in the following example.

3rd. Take the difference between the time as marked by the watch at the instant of each observation, and that of the passage over the meridian, which will give the horary angle corresponding to each altitude. Find in Table X, opposite each of the horary angles, a number which is its square, expressed in minutes and decimals of a minute, and write it on the right hand of the horary angle to which it belongs. Add together the squares of all the horary angles, then divide their sum by the number of observations, and the quotient will be the number by which the quantity found in Table IX, is to be multiplied. This product will be the correction to be added to the true mean altitude of all the observations, in order to obtain the true meridian altitude; which is to be used in the same manner as if it had been found directly by observation, and the required latitude will be obtained.

The following example will illustrate the preceding rules:—

EXAMPLE.

On the 17th of June 1793, being in south latitude 9° 52′, and east longitude 148 55′, the altitudes of the sun near the meridian were observed, for the purpose of ascertaining the latitude. It had been found from observations made in

the morning, that at 7h 50′, the watch was 1h 22′ 34″·2 behind true time. The place where we were at noon was 4′ 50″ of a degree, or 19″·3 of time, to the west of the place where the time had been observed in the morning. The elevation of the eye was 20 feet: what was the correct latitude?

The time by the watch at noon, at the place where the horary angles were observed, would be 10h 37′ 25″·8; but as the place of observation was west 19″·3 of time, the passage of the sun over the meridian would take place later by the same quantity. The 19″·3 must therefore be added to 10h 37′ 25″·8; and the time of passage by the watch, neglecting the fractions of a second, would be 10h 37′ 45″. The details of the following calculation shall not be specified: the operations which ought to be performed will easily be perceived by inspection.

The time reckoned at the first meridian, corresponding to the instant of the passage over the meridian of the place of observation, was 14h 4′, but the 17th had not commenced, and the time of the passage was therefore the 16th of June, at 14h 4′; the corresponding declination of the sun was 23° 24′ 29″ N.

Time of passing the Meridian 10h 37′ 45″.

Time by the Watch.	Intervals.	Squares of the Intervals, or Multipliers.
10h 35′ 47″	1′ 58″	3″·9
36 21	1 24	2·0
38 9	0 24	0·2
39 10	1 25	2·0
	Sum	8″·1
	The fourth. Multiplier	2·02

Quantity ascended by the sun in 1′ before passing the meridian - - - -	3″·3		
Multiplier - - - - - - -	2·02		
	6″·1		
	0·6		
Number to be added to the mean altitude	6″·7		
Sum of the altitudes of the ⊙'s lower limb	226°	1′	40″
The fourth. Mean apparent altitude of the ⊙ at noon - - - - -	56	30	25
Elevation of the eye 20 feet. Depression -	—	4	23
Remainder -	56°	26′	2″
Semi-diameter of the ⊙ - - - - -	+	15	46
	56°	41′	48
Refraction—Parallax - - - - -		—	33
True mean altitude of the ⊙. - -	56°	41′	15″
Add - - - - - - - -		+	7
Meridian altitude North - - - -	56°	41′	22″
Declination North - - - - - -	23	24	29
Sum. Altitude of the equator - -	80°	5′	51″
Complement. LATITUDE SOUTH - -	9°	54′	9″

49. In the interval of 14′, during which the observations may be continued, it is possible to take eight or ten, or even a greater number of altitudes; therefore, the errors in the calculated latitude will be greatly attenuated. The latitude may be obtained in a single day with as much accuracy as by the observations of eight or ten meridian altitudes, which require as many days as there are observations; and, if the altitudes are taken with a circle, the accuracy will be still greater.

The greatest errors arise from the uncertainty of astronomical refractions, and principally from those which influence the depression of the horizon, treated of in art. 24

and 25; but in common cases, there can be little doubt of obtaining the latitude to a minute, or even to nearly half a minute, and sometimes with much greater accuracy.

To find the Latitude from Two Altitudes of the Sun, taken out of the Meridian, and the Interval of Time elapsed between the Observations.

50. The calculation of the latitude from two altitudes taken out of the meridian, and the time elapsed between the observations, is very complicated. The limits to which this treatise is confined, do not permit us to give the demonstration in this place, but it will be found at the end of the work. The object which is here proposed, is to explain the operations which are proper to be performed in each of the methods that can be employed at sea, in order to render their application easy and familiar. This reason has induced us to give separately, at the end of this treatise, the demonstrations of all the methods which depend upon the resolution of spherical triangles.

51. This method requires us to know, whether the sun ought to pass the meridian towards the elevated or depressed pole; but such a condition cannot be productive of any inconvenience in practice. In fact, it is impossible to obtain the latitude from altitudes taken before and after noon, whenever the sun's meridian altitude exceeds 84°, that is, when his meridianal zenith distance is less than 6°; but, as we can never have so great an uncertainty in the estimated latitude, whenever this kind of observation is practicable, we shall never be liable to mistake the denomination of the pole towards which the sun passes the meridian.

52. All altitudes that can be observed while the sun is above the horizon, are not equally proper for giving the latitude with that precision which the safety of navigation

requires; those might be observed from which the results would be very defective, and even among those altitudes that might be taken in favourable circumstances, there are some from which the calculated latitudes would admit of greater precision than from others. These circumstances depend, in general, upon the interval of time elapsed between the observations, with respect to that of the horary angle, corresponding to the altitude taken nearest the meridian. The probability of an error with which the latitude may be affected, may also be estimated by the ratio which exists between the azimuths corresponding to each observation; it is these last angles of which the greatest use will be made in the following rules. The method here treated is discussed with the greatest detail in the second volume of *d'Entrecasteaux's Voyage;* and it is from this work that the following precepts have been extracted.

53. When the two altitudes have been taken on the same side of the meridian, that is, when they have been both observed in the morning or the evening, they are said to be of the same kind. When one of them has been observed before the sun passed the meridian, and the other after, they are of a different kind.

The azimuth corresponding to the altitude which has been observed nearest the meridian, or to the greater altitude, is called the less azimuth; that which corresponds to the less altitude, is called the greater azimuth.

General Precepts,

For finding the Latitude from Two Altitudes taken out of the Meridian.

54. When the meridian altitude would exceed 84°, this method cannot be employed.

The less altitude should be more than 6° or 7°.

The way made by the vessel in the interval between the observations should not exceed 12 leagues.

The watch with which the interval of time between the observations is measured, should not vary from mean time more than 3 minutes in 24 hours.

OBSERVATIONS OF THE SAME KIND.

Rules for the Altitude nearest the Meridian.

55. The nearer the greater altitude is taken to the meridian, the greater precision will be obtained in the result.

If the interval be measured with a marine chronometer, the least azimuth ought not to be greater than 40° or 45°. In the case where this measure can only be taken with a common watch, susceptible of a variation of 3 minutes in 24 hours, the least azimuth ought never to exceed 15°.

Rules for the Altitude farthest from the Meridian.

56. The interval of time elapsed between the observations should always be greater than that corresponding to the least horary angle; but as the ratio of these two quantities is subject to a variation, according as the meridian altitude of the sun is greater or less, general rules can only be deduced from the values of the azimuths corresponding to the two altitudes.

The value of the azimuth corresponding to the less altitude, or the greater azimuth, ought not to be less than about $2\frac{1}{2}$ times the value of the less azimuth. When a marine chronometer is used, the larger the former of these azimuths is, the greater precision will be obtained in the result, provided the sun has always more than 6° or 7° of altitude; and the way made in the interval between the

observations is not more than 12 leagues. With a common watch, the greater azimuth should not exceed 75°.

By following these rules, the latitude may be obtained to within about 3 minutes of the truth.

OBSERVATIONS OF A DIFFERENT KIND.

57. The nearer the two altitudes are observed to the meridian, the greater precision may be obtained in the result.

Rules for the Altitude nearest the Meridian.

58. If the interval of time be measured with a marine chronometer, the less azimuth ought never to exceed 45°; with a common watch, it should not be more than 30°.

Rules for the Altitude farthest from the Meridian.

59. The supplement of the greater azimuth, or of the azimuth corresponding to the less altitude, ought not to be less than two and a half times the value of the less azimuth. This rule is without exception when the interval between the observations is measured with a marine chronometer; but it is to be recollected, that the sun must not be below 6° or 7° of altitude, and that the way made in the interval is not to exceed 12 leagues. When a common watch is used, the less azimuth may be between 15° and 30°, and the sum of the azimuths corresponding to the two altitudes, or the azimuthal interval may be 60°. When the less azimuth is not more than 15°, the greater should not surpass 75°.

Whenever these rules are complied with, the latitude may be obtained to nearly 3 minutes of the truth.

Remark on the Application of the preceding Rules.

60. It is not necessary to know the azimuth corresponding to each altitude with a great degree of accuracy, in order to be able to judge of the precision of which the observation is susceptible; it will be sufficient to obtain it within 2 or 3°. Tables XII and XIII, the use of which has been explained in art. 40. and 41, will give these azimuths with the necessary accuracy, at least with a very simple operation, as shall be shown.

61. When the multiplier for the correction of the less altitude, on account of the way made in latitude between the observations, has been calculated, enter Table XIV, with this number, and there will be found in the same line, on the left hand, the azimuth corresponding to the less altitude. The multiplier answering to the greater altitude being calculated in a similar manner, by means of Tables XII and XIII, the azimuth that answers to it will be found in Table XIV. The two azimuths being known, it will be very easy, according to the preceding rules, to ascertain whether the circumstances of the observation are favourable, and if the result will be comprised in the limits of precision already indicated. It is essential that the proportional parts should be taken with accuracy in the Tables XII and XIII, whenever the greater altitude corresponds to an azimuth less than 30°. The same tables are no longer proper for giving the value of the azimuth, even by approximation, when it is less than 15°; but in this case, the value will be very small, and the azimuth corresponding to the less altitude may always be from 40 to 45 degrees.

Calculation of Latitude.

62. The latitude of the place where the greater altitude

has been observed cannot be directly obtained; but several other quantities must first be calculated. 1st. It is necessary to ascertain the distance of the two places which the sun occupied in the heavens with respect to the meridian and horizon, at the time the altitudes were observed; this is called the distance of the sun's places. 2nd. The angle formed by the arc of the great circle that measures this distance and the circle of declination corresponding to the least altitude, is to be calculated; this is the first angle at the sun. 3rd. The second angle at the sun, which is formed by the arc of the distance, and the vertical circle of the less altitude, must also be calculated. 4th. These two angles, added together or subtracted from each other, will give the angle that the circle of declination makes with the vertical circle of the sun, at the moment of observing the less altitude, or the angle of variation. Lastly, by means of this last angle, the latitude may be directly calculated, which will be that of the place where the greater altitude was observed.

63. Previous to entering upon the calculations which have been specified, it will be necessary to obtain the data that are to be employed. The time at the first meridian corresponding to the two instants of observing the altitudes, must first be found by means of the estimated longitude; then the two declinations answering to these instants are to be taken from the Nautical Almanac. Half the sum of these declinations taken from 90°, when the sun is in the same hemisphere with the elevated pole, will give the polar distance, which is to be used in the calculation. When the sun is in the other hemisphere, 90 degrees is to be added to half the sum of the declinations corresponding to observations of altitude.

64. The interval of time elapsed between the observations, as obtained by the watch, is the same as would have

been measured if the vessel had not changed its place; in short, whether we remain at rest, or move with great velocity, provided the instants indicated by the watch are the same, the elapsed time will always be equal to the difference of the times corresponding to the observations. But the difference of the times reckoned at the places, at the instants of the two observations, must be used in the calculations; thus, if the place where the less altitude was observed is to the eastward of that of the greater, the difference of longitude of the two places, reduced into time, must be added to the time of observing the less altitude; on the contrary, if the place of the less altitude is to the west of that of the greater, the difference of longitude must be subtracted. The difference which exists between the time of the least altitude so corrected, and the time of the watch corresponding to the greater altitude, will give an interval of time, the half of which, reduced into degrees, will be the half interval with which the calculation is to be performed. When the observations are of the same kind, that is, when both have been made in either the morning or the evening, subtract the less time, as given by the watch, from the greater, and it will give the interval of time which separated them. If the observations are of a different kind, subtract the time of the observation made before noon, from that which corresponds to the observation made after noon, increased by 12 hours.

65. The two observed altitudes should be corrected for the depression of the horizon, the semi-diameter of the sun, and the effects of refraction and parallax, according to the rules already given; there must also be another correction applied to the less altitude, for the purpose of taking into the account the way which the vessel has made in latitude during the interval between the two observations; this is to be found by the methods explained in art. 40 and 41.

66 The multiplier which serves to calculate the correction of the less altitude, will give, with the assistance of Table XIV, the azimuth corresponding to that altitude. The multiplier that agrees with the greater altitude, and also its corresponding azimuth, are to be found in the same manner; the two azimuths must then be compared together, and the ratio of their values will enable us to judge (see art. 35, and following), whether the observations have been made under favourable circumstances or not.

67. When the given quantities have been collected, and it has been ascertained that the result ought to be within the limits of the requisite precision, the latitude may be calculated according to the following rules.

1st. *Distance of the two places of the sun.* Add the logarithm sine of half the interval to the logarithm sine of the polar distance; the sum will be the logarithm sine of the half distance of the sun's places: double this, and it will give the whole distance.

2nd. *First angle at the sun.* Add the logarithm of the cotangent of half the interval to the complement of the logarithm cosine of the polar distance; the sum will be the logarithm tangent of the first angle at the sun. Half the corresponding arc will be half the first angle at the sun.

The arc answering to the logarithm tangent of the first angle at the sun should be less than 90°, if the distance from the sun to the elevated pole is less than 90°; but greater than 90°, if the polar distance exceeds 90°: thus, in the first case, the arc found in the Tables will be the first angle; in the second, it must be subtracted from 180° to obtain this angle.

The data employed in the calculation of these two quantities are the same; and they may be disposed as shown in the following Table. Immediately after having taken the logarithm sine of half the interval, the logarithm cotangent is to

be taken, and written opposite the former. The same is also to be done with respect to the polar distance; after having found the logarithm of its sine, the arithmetical complement of its cosine is to be taken.

3rd. *Second angle at the sun.* Write one above another, and in the following order; the greater altitude, the less corrected altitude, and the distance of the sun's places. Add these three quantities together, and take half their sum; from which subtract the greater altitude.

Search then, in the Tables, for the arithmetical complement of the logarithm cosine of the less altitude, and that of the sine of the distance of the sun's places. Take from the same tables the logarithm cosine of the half sum, and the sine of the difference between this half sum and the greater altitude. Add the two arithmetical complements to the two logarithms: half their sum will be the logarithm sine of half the second angle at the sun; which is to be written below that of the first, which has already been found.

4th. *Angle of variation.* When the sun passes the meridian towards the depressed pole, take half the difference of the first and second angles at the sun. But when this passage is made towards the elevated pole, take half their sum: which will be half the angle formed by the sun's vertical circle, and his circle of declination, at the instant of observing the less altitude; or half the angle of variation.

5th. *Latitude.* Below the half angle of variation, write the distance of the sun from the elevated pole; and immediately under it the less corrected altitude. Subtract the less altitude from the polar distance, and take the difference between the remainder and 90°; write half this difference below the other two numbers.

Find the logarithm cosine of half the angle of variation; add to it, first, half the logarithm sine of the polar distance, then half the logarithm cosine of the less

altitude, and, lastly, the arithmetical complement of the logarithm cosine of the half difference, referred to at the end of the last paragraph. The sum of these four numbers will be the logrithm sine of an auxiliary arc. Take the logarithm cosine of this arc, and subtract from it the arithmetical complement of the logarithm cosine of the half difference between the remainder and 90°, above found; which will give the logarithm cosine of half the sum of the latitude plus 90°. Multiply the corresponding arc by 2, and subtract 9 from the tens and hundreds of the degrees in the product; and the remainder will be the latitude of the place where the greater altitude was observed.

EXAMPLE.

On the 17th of July 1809, about 6^h 40′ in the morning, being in 43° 6′ of north latitude by account, and 148° 56′ of east longitude; when the watch was 6^h 44′ 20″, the altitude of the sun's lower limb was observed to be 21° 34′ 50″; and when the same watch indicated 11^h 12′ 36″·6, a second altitude of the same limb was taken, and found to be 65° 18′ 58″. The elevation of the eye at these two observations was about 21½ feet. In the interval between the observations, the ship had advanced 25′ 3″ of a degree in longitude towards the west, and 27′ 26″ in latitude towards the north. The latitude of the place where the greater altitude was observed is required.

The rules already given are sufficient for finding the elements of the calculation for this example; and, from an inspection of the following table, it will be easy to understand the operations which are to be performed; all details on the subject will therefore be dispensed with. It should now be remarked, however, that the common denomination of first and second observation, have not been used; it appeared that those of the greater and less altitudes would

To face page 61.

Calculation of Latitude by two Altitudes taken out of the Meridian.

July 17th, 1809.

TIME BY THE WATCH.

At the place of the less alt. - -	6h	44′	20″·0
Less alt. taken E. of the greater	+	1′	40·2
Less alt. taken to the W. - - - -	—		
Time of the less alt. corrected - -	6	46	0·2
Time at the place of the gt. alt.	11	12	36·6
Interval in time - - - - - -	4	26	36·4
Interval in degrees - - - -	66°	39′	10″
Half interval - - - - - -	33	19	30

LESS ALTITUDE.

Observed altitude $\odot$ - - - -	21°	34′	50″
Height of the eye $21\frac{1}{2}$ft. depression	—	4	31
	21	30	19
Semi-diameter of $\odot$ - - - - -	+	15	46
	21	46	5
Refraction — Parallax - - - -	—	2	15
True altitude of $\odot$ - - - - -	21	43	50
Meridian alt. less at the place of the greater alt. } Diff. of lat. - -	—	27	24
	21	16	26
Product - - - - - - -	+	31	30
Less altitude corrected - - - -	21	47	56
Half interval - - - - - - - -	33°	19′	30′
Polar distance of $\odot$ - - - - -	68	49	0
$\frac{1}{2}$ distance two places of $\odot$ - - -	30	48	50
Double. Distance - - - - - - -	61	37	40

GREATER ALTITUDE.

Observed altitude of $\odot$ - - - -	65°	18′	58″
Height of the eye $21\frac{1}{2}$ft. depression	—	4	31
	65	14	27
Semi-diameter of $\odot$ - - - - -	+	15	46
	65	30	13
Refraction — Parallax - - - -		—	22
True altitude of $\odot$ - - - - -	65	29	50

Table XII, 1st term - 3·05 Arg. - - - 3·32
Table XIII, 2d term 1·20 + 2
Multiplier - - - - - 0·15 Greater azim. 32°
Greater azim. more than triple the less.

sin. 9·7398787		cot.	0·1821029
sin. 9·9696158		comp. cos.	0·4420679
sin. 9·7094945		tang.	0·6241708

Estimated time of the less alt. -	13h 40′ 0″
Longitude East 148° 56′ or - -	9 54 0
Time at the first Meridian - -	8 46 0
Less alt. Declination of $\odot$	21° 11′ 55″N.
Greater alt. Declination of $\odot$	21 10 0 N.
Mean Declination - - - - -	21 10 57 N.
Dist. of $\odot$ from the elevated pole	68 49 3
Estimated lat. Less alt. - - -	43 6 N.
Estimated lat. Greater alt. - -	43 38·6 N.
Difference of latitude - - - -	27·4 N.

Calculation of the multiplier of the difference of latitude.

Table XII. 1st term { 1·37 Arg. 1·47.
Table XIII. 2nd term { 0·53 + 2

Multiplier - - - -	1·16	Azim. 99°
Diff. of latitude - -	27·4	
Product - - - - -	31′5	

{ When the polar distance is > 90°, subtract the 1st angle at the $\odot$ from 180° - - - - - } 1st angle at the $\odot$ - - - - - - 76° 38′ 0″

Greater altitude of $\odot$ - - - - -	63°	29′	50″	
Less altitude of $\odot$ - - - - - -	21	48	0	comp. cos 0·0322247
Distance of the $\odot$'s places - -	61	37	40	com. sin. 0·0555770
Sum - - - - - - - -	148	55	50	
Half-sum - - - - - -	74	27	40	cos. 9·4279603
Half-sum — greater alt. -	8	57	50	sin. 9·1926007
Sum - - - - - - -				18·7083627
Half-sum - - - -				sin. 9·3541813
Half 2d angle at the $\odot$	13°	3′	50″	

Half the 1st angle at the $\odot$ - -	38	19	0
Half the 2d angle at the $\odot$ - -	13	3	50

{ If the $\odot$ pass the meridian towards the depressed pole, *subtract* the 2nd angle at the $\odot$; *add* it if he pass towards the elevated pole.

Half the angle of variation - - -	25	15	10	cos. 9·9563771
Polar distance of $\odot$ - - - -	68	49	0	$\frac{1}{2}$ sin. 4·9848079
Less altitude of $\odot$ - - - -	21	48	0	$\frac{1}{2}$ cos. 4·9838876
Polar distance — less altitude -	47	1	0	
Difference from 90° - - - - -	42	59	0	
Half difference - - - - - - -	21	29	30	comp. cos. 0·0312972

Auxiliary angle - - - - - { sin. 9·9563698 / cos. 9·6300783

Cos. auxiliary angle. — Comp. cos. $\frac{1}{2}$ difference - - - cos. 9·5987811

$\frac{1}{2}$ sum of the latitude + 90° - - - - - - - - - - - 66° 36′ 30″ N.

Double — 90°. { LATITUDE at the place of the greater altitude - - - - - } - - - 43° 13′ 0″ N.

render the application of the rules more uniform, and the distinction of cases more easy. Care has also been taken to specify, in the same table, the quantities which are additive, and those that are subtractive. When the same quantities may have, in different cases, either sign, the circumstances that determine in what sense they are to be used, have been written opposite them. Thus, without any other assistance than this table, any observations may be calculated, whatever may be the circumstances under which they are made.

CHAPTER IV.

Calculation of the Horary Angle, and of the Altitude of any of the heavenly Bodies.

68. It has already been shown, that a knowledge of the time at the place where we are is necessary, for obtaining the latitude from several altitudes of the sun taken near the meridian, and it is equally essential in calculating the longitude by means of marine chronometers, and the distances of the moon from the sun or the stars: this problem may, therefore, be regarded as one of the most important in Nautical Astronomy. We shall therefore give, in this chapter, the means of finding the true time at the vessel, then treat of the inverse method, which consists in calculating the altitude of any heavenly body, from knowing the time at the place of observation. The calculation of the altitude is useful in certain cases, where it is required to find the true distance of two of the heavenly bodies when the apparent distance has been observed. These two problems will then be applied to that of longitude, in the two following chapters, in which the methods to be used in calculating the longitude by marine chronometers, and the distances of the heavenly bodies, are explained.

Calculation of the Horary Angle.

69. It was said at the commencement of this Treatise, that the astronomical day is the interval of time elapsed between the passage of the sun over any meridian, and his return to the same meridian. This interval is divided into 24 equal parts, which are called hours, and are so reckoned, that when the circle of the sun's declination, by virtue of its diurnal motion, has passed over 15° of the equator, we reckon one hour, and when it has passed over 30°, we count two hours. It follows from this, that when this circle of declination is at 180° from the meridian taken for the first, we reckon 12 hours; and, lastly, at the moment of the sun's return to the same meridian, this circle of declination has passed over 360° of the equator, and then the 24 hours of the day are elapsed. Those parts of time that have the same denomination, answer to equal parts of the equator; they may therefore be valued in degrees. It also follows, from what has been said, that the time at any place is equal to the difference of right ascension between the celestial meridian of that place and the circle of the sun's declination, at the given instant, or to the spherical angle formed by the meridian and the circle of declination.

70. From noon, or the moment of the sun's passage over the meridian to his setting, and even to the moment of his arrival at the meridian, 180° from that of the place, the circle of declination becomes more distant from the meridian of that place; after which, it approaches it until the sun return to the meridian again. The least distance of the circle of declination from the meridian, at any given time, is called the Horary Angle. In the first half of the astronomical day, that is, from noon to midnight, the horary angle is equal to the hour itself; but in the latter half, or

from midnight to noon, the time is the difference between the horary angle and 360°, or 24 hours, when the day is reckoned astronomically; or to the difference between the same angle and 180°, or 12 hours, when the day is taken in a civil sense: this is the angle which is directly given by the following calculations.

71. As the altitude of the sun varies every moment he is above the horizon, the time, or the horary angle, may therefore be ascertained by observation of his altitude. From the rising of the sun, to his passage over the meridian, his altitude increases at first very rapidly, afterwards his movement in altitude becomes slower; and lastly, when he has arrived at the meridian, this motion ceases. When the sun begins to descend towards the horizon, his motion in altitude increases in the same proportion as it diminished before he arrived at the meridian; that is, the corresponding motions, at the same altitudes, are always equal to each other, or, may be considered as being so. The circumstances in which observations on the sun's altitude give the horary angle with the greatest accuracy, are those in which his motion in altitude is the most rapid; when the sun is near the meridian, observations of his altitude are not proper for ascertaining the horary angle. According to theory, the greatest motion in the sun's altitude is at the instant of his passage over the prime vertical, or when the azimuth of the sun attains its greatest value. Observations of altitude intended for the calculation of the horary angle, should therefore be made as near this instant as possible. By means of the sun's declination, and the latitude of the place, there may be found, in Table XV, the altitude which the sun has on the prime vertical, or when his azimuth is the greatest; the observations should, therefore, be made when the sun has nearly attained the altitude given by this table.

This table must be used only when the sun and the observer are both in the same hemisphere, that is, when the declination of the sun, and the latitude of the place of observation have the same denomination; for, in the contrary case, or where the declination of the sun and the latitude have different names, the sun can never arrive at the prime vertical. Then the moment when the sun's azimuth is the greatest, is that of his rising or setting; the observations should therefore be made when the sun is near the horizon. But altitudes less than 6° or 7° must not be used, as below this altitude, the refraction is very uncertain, and might occasion sensible errors in the time which results from the calculation.

72. The latitude by account is one of the data necessary in the calculation of the horary angle; and this may be affected with errors sufficiently great to have a sensible influence on the result. The case in which the influence of this error is the least possible, also takes place when the sun passes the prime vertical, or attains his maximum azimuth. The error in the horary angle arising from latitude, will therefore be diminished the most, when the rules are followed which have been given relative to the circumstances in which the motion in altitude is the greatest.

73. In general, the nearer the azimuth corresponding to the observed altitude approaches to 90°, the less error there will be in the result. The error which may be apprehended in the horary angle will, on the contrary, be greater, as the observations are made nearer the meridian, and as the corresponding azimuth is less. Hence, observations of altitude are not proper for ascertaining the time at the place where they are made, during some time before and after the sun's passage over the meridian. But the results will always have the precision which the safety of navigation requires, if the altitudes are observed before half past 10 in the morning,

and after half past one in the afternoon. Then the time at the place may be obtained to about 8″ or 10″ of time.

When the day is cloudy, it may happen, that the observations cannot be made under the most favourable circumstances; and that an altitude taken between half past 10 and noon, or else between noon and half past one, may still be proper for ascertaining the time with sufficient accuracy. Then the azimuth corresponding to the altitude must not be less than 20°; but in this last case, there cannot be any certainty of ascertaining the time within less than 20″ or 25″. It will be easy to ascertain if the corresponding azimuth is 20°, by the assistance of the Tables XII and XIII. These Tables have, therefore, the advantage of showing the precision of which the observations of the horary angles are susceptible; as well as that of giving the latitudes obtained from two observations taken out of the meridian. The multiplier proper for the observed altitude may be obtained by the rules given in art. 40. and 41; and in Table XIV there will be found the azimuth that corresponds to it. From the magnitude of this azimuth, we may judge of the degree of confidence that should be placed in an observation made near the limits within which the result may be defective. If the calculated azimuth is below 20°, the observations should be entirely rejected: even in the case where it does not exceed 30°, and where the latitude could not be observed, it will be necessary to conduct ourselves with circumspection, with respect to the result of the observation.

74. Whenever it is required to obtain the time at any place by observations of the sun's altitude, these altitudes should be taken as near as possible to the most favourable circumstances. Several altitudes of the sun may be observed in succession, and the hour, minute, and second corresponding to each observation, noted down. It will then be easy to deduce from them the mean time corres-

ponding to the mean altitude; after which, the calculation is to be performed in the following manner.

75. First, find by means of the estimated time at the place, and the longitude by account, the time at the first meridian at the moment of the observation. This time will serve to find, in the Nautical Almanac, the sun's declination, from which his distance from the elevated pole is derived, which should be employed in the calculation. Then the necessary corrections must be made in the observed altitude for obtaining the true altitude of the sun's centre.

Then write in the following order, the sun's true altitude, the latitude, and the polar distance: take the sum of these three quantities, and half this sum; next, from this half sum subtract the true altitude. Search in the Tables the arithmetical complement of the logarithm cosine of the latitude, and the arithmetical complement of the logarithm sine of the polar distance. Add these two arithmetical complements to the logarithm cosine of the half sum, and to the logarithm sine of the half sum minus the true altitude, and half the sum thus obtained will be the logarithm sine of half the horary angle. Find in the Tables the corresponding arc, which will be half the horary angle reckoned in degrees. This arc, multiplied by two, will therefore give the horary angle, which will be reduced into time by multiplying the product by four. The calculation will be abridged, if the arc found in the Tables be multiplied at once by eight; and by reckoning the seconds of the product for thirds, the minutes for seconds, and the degrees for minutes, the horary angle of the sun will be had in time. If the observation was made in the afternoon, this horary angle will be the hour at the place; if in the morning, its complement to 24 hours will be the time reckoned astronomically, and its complement to 12 hours will be the civil time: but, in this latter case, care must be taken to specify whether the observation was made in the morning or evening.

76. The time thus found is called true time, because it is immediately concluded from the actual position of the sun, with respect to the place of observation. It is the sun which, by virtue of the earth's diurnal motion, causes the successive return of day and night; his annual motion also regulates the periodic return of the seasons; it is from this body that the most remarkable divisions of time are derived, and those which regulate the transactions of civil life.

Example.

The 14th of July 1792, at about $8^h\ 18'$ in the morning, being in $5°\ 55'\ 45''$ of South latitude, and $152°\ 3'$ of East longitude, the following observations were made, from which it is required to reduce the time at the place of observation. The elevation of the eye was 14 feet.

Time by the watch,				
	$8^h\ 8'\ 48''$	Sum of the ☉'s altitudes	-	$172°\ 46'\ 20''$
	$9\ \ 19$	Mean altitude of the ☉	-	$28\ \ 47\ \ 43$
	$10\ \ 3{\cdot}5$	Depression	-	$-\ \ 3\ \ 40$
				$28°\ 44'\ 3''$
	$11\ \ 7$	Semi-diam. of the ☉	-	$+\ 15\ \ 47$
				$28°\ 59'\ 50''$
	$12\ \ 8$	Refract. — Parallax	-	$-\ \ 1\ \ 36$
	$12\ \ 58$	True altitude	-	$28°\ 58'\ 14''$
Sum	$64'\ 23''{\cdot}5$			
Mean time	$8^h\ 10'\ 43''{\cdot}9$			

The time at the first meridian, concluded from the estimated time at the place and the longitude by account, is $10^h\ 10'$. The corresponding declination is $21°\ 39'\ 30''$ N.; as the sun is in the contrary hemisphere to the observer, $90°$ must be added to the declination, and the sun's distance from the elevated pole will be $111°\ 39'\ 30''$.

It will be useless, in calculating the horary angle, to take the proportional parts for the seconds; consequently, there may be added to, or subtracted from, the three given quan-

tities of the calculation, the number of seconds necessary to cause the logariths of the trigonometrical lines which correspond to them, to be found directly in the Tables. Attention must also be paid to make these small changes in the given quantities, so that the tens in their sum may be an even number, as follows:—

True alt. of the ☉	28° 58′ 10″		
Latitude - -	5 55 40	Comp. cos. -	0·0023285
Polar distance	111 39 30	Comp. sine	0·0317968
Sum - -	146° 33′ 20″		
½ Sum - - -	73 16 40	- - cos.	9·4589882
½ Sum — altitude	44 18 30	- - sine	9·8441785
		Sum	19·3372920
		½ Sum sine	9·6686460
		Half the horary angle	27° 47′ 30″
		Multiplying by - - - - -	8
When the observation was made in the afternoon. Horary angle - - - - - - - -			3h 42′ 20″
When the observation was made in the morning, subtracting from 12h - - - - -			8h 17′ 40″
	Time by the watch - - - - - -		8 10 43·9
	The watch is too slow by - - -		0h 6′ 56″·1

The time by the watch is less than the time at the place by 6′ 56″·1; the watch is therefore slower than true time, by this quantity. If the time by the watch had been the greater, the difference of the two would have been what it was too fast, or before true time.

77. The time may also be obtained by observing the altitude of a star. The rules already given relative to the observations of the sun's altitude must be followed, both for taking advantage of the most favourable circumstances, and for calculating the horary angle. In this case, the horary angle

of the star will be the difference in right ascension at the instant of the observation, between the celestial meridian of the place and the circle of declination of the star. The right ascension of the star's circle of declination, or the right ascension of the star itself, being known, it will be easy to derive from it the right ascension of the meridian; which is done in the following manner:—When the altitude of the star has been observed to the west of the meridian, add its horary angle to its right ascension reduced into time; the sum will be the right ascension of the meridian. When the star is observed towards the east, subtract its horary angle from its right ascension, and the remainder will be the right ascension of the meridian. Then take the right ascension of the sun from that of the meridian, and there will be obtained the difference of the right ascensions of the sun and the meridian, or the hour at the place. Instead of the right ascension of the sun, the Connaissance des Tems contains the distance between the equinox and the sun *, which is the complement to 360°, or 24 hours; to obtain the time at the place, it will therefore be necessary to add this quantity to the right ascension of the meridian: if the sum exceeds 24 hours, the excess will be the time required. The distance from the equinox to the sun, should be calculated for the time at the first meridian, deduced from the estimated hour at the place and its longitude; when the time resulting from this calculation differs more than 5 minutes from the estimated time at the place, the distance from the equinox to the sun may be calculated again, and a second result will be obtained much more accurate than the former. It would be possible to arrive at the greatest degree of accuracy, by

* The sun's right ascension is taken immediately from the second page of the month in the Nautical Almanac, and must be added to the right ascension of the meridian, or subtracted from it, as directed in the rule. *Trans.*

making a third calculation of the distance from the equinox to the sun; but the second will always have a sufficient degree of precision.

EXAMPLE.

Being in 21° 11′ of south latitude, and 30° 6′ west longitude, on the 20th of May 1810, at 10^h and ¼, several altitudes of *Antares* were observed, the mean of which was 59° 22′ 30″. The mean time by the watch was 9^h 43′ 55″; and the elevation of the eye 19⅝ feet nearly. Required the true time of the observation.

The hour at the first meridian corresponding to the time at the place is 12^h 15′. The declination of *Antares* is 25° 59′ 57″ south; and its distance from the elevated pole 64° 0′ 3″. Its right ascension 244° 27′, and in time, 16^h 17′ 48″. The distance from the equinox to the sun is 20° 11′ 56″·7.

Apparent altitude of Antares - - - - - -	59° 22′ 30″
Elevation 19⅝ feet. Depression - - - - -	— 4 21
	59° 18′ 9″
Refraction - - - - - -	0 34
True altitude of Antares - - - - - - - - -	59° 17′ 35″

True alt. of the star 59° 17′ 40″

Latitude - - -	21	11	0	Com. cos. -	0·0303842
Polar distance -	64	0	0	Com. sin. -	0·0463398
Sum - - -	144	28	40		
½ Sum - - -	72	14	20	cos. -	9·4843696
½ Sum — altitude	12	56	40	sin. -	9·3502600
				Sum - - - -	18·9113536
				Half-sum. Sin.	9·4556768
				Half horary angle	16° 35′ 30″
				Multiplying by - - -	8
				In time - - -	2^h 12′ 44″

	In time - - - - -	2^h	$12'$	$44''$
	Right ascen. of the star	16	17	48
The star to the east. *Differ.* } Right ascen. of the merid.		14^h	$5'$	$4''$
The star to the west. *Sum* }				
	Dist. from the equin. to ⊙	20	11	57
	Sum. Time at the place	10^h	$17'$	$1''$
	Time by the watch - -	9	43	55
	Watch behind true time	0^h	$33'$	$6''$

The time which results from the calculation, differs only 2′ from the estimated time at the place; it is therefore not necessary to make a second calculation for the distance from the equinox to the sun.

Calculation of the Altitudes of the heavenly Bodies.

78. This problem is the reverse of the preceding one. In the former, the horary angle is found from an observation of the altitude; in this, the altitude is to be calculated by means of the horary angle: this requires a knowledge of the time at the place. When the altitude of the sun is to be calculated, the horary angle is easily found. It is equal to the true time, if the altitude is to take place after noon; and it is equal to the complement of the true time, to 24 or to 12 hours, when the altitude is to take place in the morning, or before noon. But when it is the altitude of the moon or a star that is required, the horary angle must be calculated in the following manner.

79. First, by means of the longitude, find the time at the first meridian corresponding to the time at the place, and take from the Nautical Almanac, the sun's right ascension. Add this right ascension to the time at the place, and subtract 24 hours from the sum, if necessary, and the result will be the right ascension of the meridian. The difference between the right ascension of the meridian and

the right ascension of the moon or a star, which has been calculated for the instant at which the altitude is required, will be the horary angle of the moon or the star at the time proposed. Then find, in the Nautical Almanac, or Connaissance des Tems, the declination of the moon or star at the same instant, from which its distance from the elevated pole is obtained. The horary angle, the polar distance, and the latitude, are the three necessary data for the calculation, which may then be performed in the following manner.

80. Write down, first, the horary angle, and take its half; below this half, write the distance of the heavenly body from the elevated pole; and immediately after it the latitude. Then subtract the latitude from the polar distance, and take the difference between the remainder and 90°; write half this difference below. Take from the Tables, the logarithm cosine of half the horary angle; write below it half the logarithm sine of the polar distance, and half the logarithm cosine of the latitude; lastly, take the arithmetical complement of the logarithm cosine of the half difference from 90°. The sum of these four logarithms will be the logarithm sine of an auxiliary angle; write down the logarithm cosine of this auxiliary angle, and subtract from it the arithmetical complement of the logarithm cosine of the half difference from 90°. The remainder will be the logarithm cosine of the half-sum of 90° plus the altitude; double the arc which corresponds to this logarithm cosine, and, after having subtracted 9 from the tens and hundreds of the degrees, the remainder will be the true altitude required.

81. When it has been impossible to observe the altitudes of the heavenly bodies, the distance of which has been taken, they may be calculated by this method; they serve, as will shortly be shown, to correct this distance for effects of refraction and parallax. An error of a minute in the calcu-

lated altitude cannot have a sensible influence on the true distance; the seconds may therefore be neglected in making the calculations, and the logarithms may be taken only to five places of decimals. The preceding rules are applied to the calculation of the altitude of a star, and to another of the moon, in the following examples.

EXAMPLE I.

On the 19th of June 1793, being in south latitude 9° 45′ 50″, and 148° 43′ of east longitude; when a watch indicated $3^h\ 41'\ 5''\cdot5$, it was found by observations of the sun's altitudes, that the watch was too slow by $1^h\ 21'\ 34''\cdot3$. It is required to find the altitude of *Antares*, when the time by the same watch was $6^h\ 8'\ 10''\cdot8$. Between these two observations the vessel had advanced 1′ towards the north, and 4′ in longitude towards the east.

Time by the watch - - - - -	6^h	8′	10″·8
Watch too slow (*Add*) - - - -	1	21	34·3
True time - - - - - - -	7^h	29′	45″·1
The place of the second observation is 4′ to the east of the first, or 16″ of time (*Add*)			+ 16
True time at the place of the required altitude	7^h	30′	1″·1
Estimated time at the first meridian -	21^h	35′	
True time at the place of the altitude -	7^h	30′	1″·1
Dist. from the equinox to the ☉. (*subtract*)	18	6	54·6
Right ascension of the meridian - -	13^h	23′	6″·5
In degrees - -	200	46	38″.
Right ascension of *Antares* - -	244	11	40
Horary angle - - - - - *Antares* east of the meridian - - -	43°	25′	2″
Latitude of the place of the altitudes, S.	9	44	50
Declination of *Antares* - -	25	57	30 S.
Distance from the elevated pole - -	64	2	30

Half the horary angle -	21° 43′	cos. - -	9·96808
Polar distance - - -	{ 64 3	½ sine -	4·97692
Latitude . - - -	{ 9 45	½ cos. -	4·99684
Polar distance—Latitude	54 18		
Difference from 90° -	35 42		
Half difference from 90°	17 51	com. cos.	0·02143
		Sine auxiliary angle -	9·96322
		Cos. auxiliary angle -	9.59627
(Cos. auxiliary angle — com. cos. ½ differ.) cos.			9·57484
	½ (90° + altitude)	-	67° 56′
(Double — 90°) TRUE ALTITUDE of the star		-	45° 52′

EXAMPLE II.

The given quantities being the same as in the preceding example, required the altitude of the moon at the same instant.

Estimated time at the first meridian -	21h 35′
Right ascension of the meridian -	200 46′ 38″
Right ascension of the moon - -	208 7
Horary angle of the ☾, to the east -	7 20′ 22″
Declination of the moon - -	7 25 0 S.
Distance from the elevated pole -	82 35

Half the horary angle - -	3° 40′	Cos.	9·99911
Polar distance - - - - -	82 35	½ Sin.	4·99817
Latitude - - - - - -	9 45	½ Cos.	4·99684
Polar dist. — Latitude -	72° 50′		
Difference from 90° - -	17 10		
Half diff. from 90° - -	8 35	Com. cos.	0·00489
		Sin. auxiliary angle -	9·99901
		Cos. auxiliary angle -	8·82888
(Cos. auxiliary angle — com. cos ½ differ.) cos.			8·82399
	½ (90° + altitude)	-	86° 10′
(Double — 90°) TRUE ALTITUDE of the moon			82° 20′

CHAPTER V.

On regulating Marine Chronometers, and employing them in the Determination of Longitude.

82. The difference of longitude of any two places being equal to the difference of time reckoned at the same instant at both places, if a well regulated watch be taken on board, which will preserve the time at the place from which the vessel sails, it will show the time at the same place at every subsequent instant. Observations of the sun's altitude will also make known the time at the several places of the vessel at these instants; hence it follows, that watches may be equally employed in finding the difference of longitude between the place of departure and each of those where the altitudes are observed, or even the absolute longitude, if it can be ascertained how much the watch is too fast or too slow, with respect to the time at the first meridian. This property of marine chronometers has given them the name of time-keepers. It is conceived to be impossible that a watch should preserve exactly the time at the place of departure; but watch-making has been carried to such perfection, that it may be supposed, without apprehending any considerable error, that the daily variation of a watch is the same quantity. Thus, when this error is known, the watch may be used for ascertaining longitude. The method of finding the quantity which a watch varies daily from the

time at the port sailed from, shall first be shown, and then the manner of calculating the longitude.

On regulating Marine Chronometers.

83. The method of comparing the time by a watch with true time, or that which has been immediately concluded from observations, has already been explained. It has been shown that parts of time having the same denomination, were measured by equal parts of the equator, which the circle of the sun's declination describes during the diurnal revolution of the earth. Thus, 24 hours always answers to 360°, and 1 hour to 15°. The earth always occupies the same time in making one revolution, and its motion on its axis is uniform; whence, if the sun remained immoveable, or if his motion of right ascension were uniform, it is evident that equal parts of the equator would always be passed over by the circle of the sun's declination in equal times. But the changes in right ascension are subject to the inequalities of the sun's motion in his orbit, and may not be the same for equal intervals of time: from which it follows that the subdivisions of true time, having the same denominations, ought not to be equal to each other. These inequalities arise also from this, that the equal parts of the ecliptic, intercepted between two circles of declination, do not always differ by the same quantity, from the parts of the equator which are intercepted between the same circles: the arc of the ecliptic is greater than that of the equator, when the two circles of declination are near the equinoxial points; it is, on the contrary, smaller when the circles of declination are near the solstices. It results from the combination of these two causes, that at certain times of the year, two consecutive days differ from each other by a quantity sufficiently sensible; and as their increase or

decrease operates progressively, it follows that the hours of true time are not equal to each other: the same for minutes and seconds. At the end of December, the true days differ by half a minute; but for the greatest part of the year the differences are much less, and become nearly insensible for an interval of two or three hours: this is the reason they were not attended to in calculating the horary angle of a heavenly body, and the time which ought to be given at noon by a watch that has been compared with true time in the morning or evening. But it is not the same when it is required to regulate a marine chronometer intended to give the longitude.

84. The mechanism of watches has been so conceived as to give to the wheels, and consequently to the hands, a motion as uniform as possible; these hands ought, therefore, to describe on the dial-plate equal angles in equal times. The comparison of the time given by a watch with true time, the corresponding intervals of which are unequal, is therefore not proper to give an idea of the regularity of its movements. Astronomers who refer the positions of all the heavenly bodies to those of the fixed stars, compare the motions of clocks and watches to a uniform motion taken immediately in nature, and for this purpose they make use of sideral time. A sideral day is the interval of time which elapses between the passage of a star over the meridian and its return to the same meridian. The stars being fixed, and the motion of the earth on its axis uniform, the circles of declination of the stars ought to describe, on the equator, equal arcs in equal times. The hours of sideral time, as well as their subdivisions, are all equal to each other, and may therefore be used in ascertaining the regularity of the motions of a clock or a watch.

85. Mariners make most of their observations on the sun; and when they observe the other heavenly bodies, they refer

their positions to that of the sun. They are therefore obliged to compare the motions of marine chronometers with another uniform motion, which approaches nearer the real notion, by virtue of which, the circle of the sun's declination passes over the equator. This motion is purely artificial, and does not exist in nature, but has been obtained by a very ingenious hypothesis. It was supposed that a circle of declination, setting off at the same time as the sun from the point where he commences his motion, moved uniformly over the equator, and passed over its whole circumference in the same time as the sun described the ecliptic. This imaginary circle of declination ought to advance on the equator each day, in proceeding from west to east, through a space equal to 59′ 8″; but the quantity which the sun's circle of declination really advances is also known; the position of the imaginary circle of declination, with respect to the real one, is therefore known at any instant: likewise, the times between the passage of this circle over any meridian, and its return to the same meridian, will always be equal to each other; and the equal parts of the equator that are described in consequence of the diurnal motion, always correspond to the equal intervals of time. The time which is derived from the position which the supposed circle of declination ought to have on the equator, is called mean time, to distinguish it from true time, which is immediately derived from the real position of the sun; mean time has the advantage over true time, as it is susceptible of being used for verifying the movements of marine chronometers.

86. The interval reckoned in mean time, is equal to the arc of the equator comprised between the meridian of the place and the circle of declination of mean time; this arc, like that of true time, ought to be reckoned from east to west. The difference between true and mean time, is equal to the angle formed by the real circle of the sun's declination

and that of mean time, or that measured by the arc of the equator comprised between these two circles; that is, equal to the difference between the sun's real right ascension and his mean right ascension.

This difference is what is called the equation of time. The motion of the circle of declination of mean time is sometimes quicker, and sometimes slower, than that of the sun's declination; it will therefore be sometimes before, and at others after this last. When it is before it, the equation of time must be added to the true time which is obtained directly from observation; when the circle of declination of mean time is after that of the sun, the equation of time is to be subtracted from the true time, to obtain the corresponding mean time.

The equation of time is generally given in Ephemerides for every day at noon; but in the Connaissance des Tems, instead of the equation of time, there is inserted the time which a clock or watch, regulated according to mean time, ought to give at the instant of the sun's passage over the meridian *. This quantity is denoted by the title of mean time at true noon; and is given for every day at the instant of true noon at the observatory at Paris; it will be easy to calculate it for any other instant, by the rules already given in the first chapter. When the mean is before the true time, the number that is found in the Connaissance des Tems is equal to the equation of time; and it is to be added to the hour obtained from the calculation of the horary angle, when mean time is required. But when the mean time is slower than the true, the equation of time is subtractive; but in this case the mean time at true noon is its

* In the Nautical Almanac, it is the equation of time that is given in the second page of every month, for every day at noon; and which is to be added to the time obtained from the calculation, or subtracted from it, as there directed, in order to obtain the mean time required. *Trans.*

complement to 12 hours; and, to obtain mean time, it will be equally necessary to add the quantity which is found in the Connaissance des Tems, to the hour that results from the calculation of the horary angle; and then 12 hours must be subtracted from their sum. From what has been said, it will be easy to understand the following rules.

87. When the true time corresponding to any instant is known, and the mean time answering to the same instant is required; the proposed time is to be added to the mean time at true noon.

If the mean time be known, the mean time at true noon must be subtracted from it, and the remainder will be the true time corresponding to the same instant.

88. Altitudes of the sun intended for the regulation of marine chronometers, should be taken as near as possible to the instant when he passes the prime vertical: that is, when he attains the altitude given in Table XV. In the case when the sun is not in the same hemisphere as the observer, the observations of altitude may commence when he is at least 7° above the horizon. Then the errors of the estimated latitude, and those of the altitude, will have the least possible influence upon the calculated time. Six altitudes may be taken in succession; and the hour, minute, and second, answering to each observation written down; and the apparent mean altitude corresponding to the mean time of the observations taken. The calculation of the horary angle should be performed according to the rules given in art. 75; and it will give the true time corresponding to the mean time by the watch. The mean time at true noon, taken from the Connaissance des Tems for the nearest period at the first meridian, must be added to the true time, and the corresponding mean time will be obtained; or if the Nautical Almanac be used, the equation of time must be added or subtracted as it is preceded by the sign + or —: from

which it will be easy to deduce the gain or loss of the watch with respect to mean time, at the instants in which the observations were made.

Suppose that several days after the first observations had been taken, they were repeated, the mean time corresponding to the mean of the second set of observations must be calculated in the same manner; and the gain or loss of the watch may be deduced, with respect to the mean time of this second set of observations.

If the gain or loss of the watch, found from the second series of observations, is the same as that found from the first, it will be a proof that the watch has exactly kept mean time during the interval. But if the gain from the second observations be greater than that from the first, the motion of the watch has been quicker than that of mean time; and the difference of the two quantities gained will be the gain of the watch during the interval. If the gain from the second series of observations had been less than that from the first, the watch would have lost in the interval a quantity equal to the difference of the two gains, as determined from the calculations of the horary angles. In the case in which the watch may be found to be slower than mean time, an increase in the loss as found from the first, would indicate that the watch has lost between the two epochs at which the observations were made: a diminution in the loss would show, on the contrary, that the watch had gained with respect to mean time. When the gain or loss of the watch in the interval between the observations is known, the gain or loss in 24 hours may be found in the following manner. This last quantity is what is called the diurnal variation of the watch, or more simply its rate. This proportion will give the rate or diurnal variation, viz. as the interval between the observations is to 24 hours, so is the gain or loss in that interval to the diurnal variation;

which will be obtained by multiplying the second and third terms together, and dividing the product by the first term. The following is an example.

It is essential to remark, that in the calculation of the horary angle, the seconds of a degree must be used, and the proportional parts taken, to obtain the logarithms of the trigonometrical lines which enter into the calculation.

EXAMPLE.

On the 29th of March 1793, in the harbour of Tongataboo, in 21° 7′ 35″ South latitude, 177° 33′ 14″ West longitude, the altitudes of the sun's lower limb were taken in the morning. The mean time was $7^h\ 34'\ 28''\cdot82$, and the mean altitude of the sun's centre 19° 23′ 13″·4. The corresponding true time is to be calculated by art. 75, and the absolute gain or loss of the watch, with respect to mean time, deduced from it in the following manner:

True time of the observations - -	$7^h\ 29'\ 0''\cdot89$
Mean time at true noon - - - -	$0\ \ 4\ \ 54\cdot23$
Mean time of the observations - -	$7^h\ 33'\ 55''\cdot12$
Time by the watch - - - -	$7\ \ 34\ \ 28\cdot82$
The 29th of March at $7^h\ \frac{1}{2}$, the watch was before mean time - - - - -	$0^h\ 0'\ 33''\cdot7$

In the morning of April 7th, being at the same place, a second series of observations were taken. The mean time by the watch was $7^h\ 57'\ 3''\cdot23$, and the apparent altitude of the sun's centre was 23° 26′ 20″. The operation is to be performed in the same manner as for the former observation.

True time of the observations - -	$7^h\ 53'\ 31''\cdot32$
Mean time at true noon - - - -	$0\ \ 2\ \ 10\cdot98$
Mean time of the observations - -	$7^h\ 55'\ 42''\cdot30$
Hour by the watch - - - - -	$7\ \ 57\ \ 3\cdot23$
The 7th of April at $7^h\ 53'$, or the 6th at $19^h\ 53'$, the watch was too fast with respect to mean time - - - - -	$0^h\ 1'\ 20''\cdot93$

The 7th of April, at 7^h 53′, watch too fast by	0^h 1′ 20″·93
The 29th of March, at $7^h \frac{1}{2}$ too fast by -	0 0 33·70
In nine days the watch had gained - -	0′ 47″·23
In 24 hours - - - - - -	+ 5·24

89. When the vessel is at anchor, and the horizon is not bounded by land, the altitudes intended for calculating the diurnal variation of the watch may be observed with a sextant or a reflecting circle. The observations should be made near the sun's passage over the prime vertical, or near the instant of his greatest azimuth; and, the latitude of the anchorage may be obtained with a sufficient degree of accuracy. But notwithstanding all these precautions, there is still reason to apprehend an error of 3 or 4 seconds in the time; and even sometimes an error a little greater. The observations should not therefore be limited to a single series of six altitudes, as is generally done at sea. It will be better to observe three or four series; and then it will be probable that the mean gain or loss of the watch derived from all these, will have a precision of 2 or 3″. The gain or loss of the same watch in the interval of the observations may therefore be affected with an error double of these quantities, that is, of 4″ or 6″, this error will take place when the errors of the first and second days of observation have their greatest values, and act in a contrary sense. In this case, the interval between the observations should exceed 6 days, that the probable error of the diurnal variation may be less than a second. Such an error is considerable; the following means of attenuating it should not be neglected.

90. It has been remarked, that the same observer measures all the altitudes either a little too great or a little too small, the errors arising from this defect of sight, would therefore take place in the same sense in all the altitudes, but those errors, which will influence the time calculated from observations taken in the morning in one direction,

will have an influence in a contrary direction on the time concluded from those taken in the evening. The greatest errors will consequently take place in the gain or loss derived from comparing the result of an observation taken in the morning, with the result of an observation taken in the evening; hence it is necessary to compare together the results from observations in the morning only, and the results from observations taken in the evening with each other. The probable error in the gain or loss calculated in this manner will not be more than about 3", and at the end of 6 days, we may conclude that the diurnal variation has been obtained to nearly half a second. A greater degree of precision may even be attained, by taking a mean between the diurnal variations which results from observations taken in the morning, and that which results from those taken in the evening. The contrary will take place with respect to the absolute gain or loss of the watch, the first day of the observations, which, as well as the diurnal variation, should be used in calculating the longitude: the mean between the result from the observations of the morning, and that from those of the evening, must be taken. Then the errors which are of such a nature as to act in opposite ways on these two results, will only influence the gain or loss of the watch by half their difference.

91. When the horizon of the sea cannot be seen, the observations must be made on land. The best means undoubtedly is, to take the altitudes with the repeating circle furnished with a level, the description and use of which has been given by M. Biot, at page 273 of the first volume of his Treatise on Physical Astronomy, in such a manner as to leave nothing to be desired. But the object of this work is to show the use that may be made of reflecting instruments; and we shall therefore describe a new instrument proper for observing the altitudes of the sun, when the

horizon of the sea is not visible. An artificial horizon is then to be used. The principal piece in this instrument is a round plane glass, set in a brass frame, sustained by three screw feet, the use of which is to place the glass in a horizontal position. The under surface of this glass is unpolished and blacked, so that the image of the sun can only be reflected by the upper surface, which should be carefully polished, and an exact plane: by this means, the errors that might arise from a defect of parallelism in the two surfaces are avoided. The artificial horizon, such as here described, should be placed on a very firm table or on the ground; then an air level is to be laid on the upper surface of the glass, and the feet screws turned to level the instrument. When the bubble rests in the middle of the tube, in all positions of the level, the surface of the glass is in a horizontal plane.

Let it now be supposed, that the direct rays of the sun fall upon the glass; they will be reflected so that the angle of incidence will be equal to the angle of reflection; and, since the surface of the glass is in a horizontal plane, each of these angles will be equal to the sun's altitude. The image that arrives at the eye by the reflected rays will appear to be depressed below the horizontal plane, by a quantity equal to the elevation of the direct image. Thus the angle formed at the eye of the observer, by the rays which proceed, on the one part from the reflected image in the glass, and from the direct image on the other, will be double his altitude. This angle may be measured with a reflecting instrument, by taking the distance from the direct to the reflected image; that is, by making the image reflected by the great mirror of the instrument, and that reflected by the artificial horizon, coincide in the field of the telescope. If the nearest edges of these two images be brought into contact, they will give double the altitude of the sun's lower

limb; and if their most distant edges be brought into contact, double the altitude of the upper limb will be obtained. The nearest and farthest edges should therefore be observed alternately, and then the apparent altitude of the sun's centre will be directly obtained, by dividing the sum of an even number of altitudes by double the number of the observations. The altitudes of the sun near the meridian, and the meridian altitude, may be observed with an artificial horizon; but as the angles measured with this instrument are double of the altitudes, its use is limited. The artificial horizon will not answer when the altitude of the sun exceeds 63°, for reflecting instruments cannot obtain the measure of angles more than 126 degrees.

On finding Longitude by Marine Chronometers.

92. Marine chronometers, as already remarked, preserve such a regularity in their movements, that these may be considered as uniform during a certain lapse of time, without apprehending any material error. It amounts to the same to suppose that the diurnal variation at the place of departure remains always the same during the voyage, which immediately succeeds the epoch at which the observations had been made. When it is wished that the rate of a chronometer or watch should vary as little as possible from this supposition, the greatest care should be taken that it do not experience any sudden jerks, or even any strange motion that might alter the duration of the oscillations of the balance by which its movements are regulated. The first rule therefore which ought to be observed, is never to carry it about one. It has been observed, that a chronometer which had been regulated, while suspended vertically, changed its rate when it was placed in a horizontal position; hence the chronometer should be kept in the same position as it was

when the diurnal variation was observed. The common practice is to place it flat in a box or case, which should always remain in a horizontal position. It would be advantageous that it should be in a place where the rays of the sun never penetrate, in order to avoid frequent and sudden changes of temperature. It would also be best to place it near the centre of motion of the vessel, that its motion might have the least possible influence on the movements of the balance. In taking altitudes or distances, a good seconds watch may be used, which has been compared with the chronometer before the observations are made; and the comparison will give the time by that watch which ought to correspond to the mean time of the observations. A second comparison should also be made after the observations are finished, to ascertain if the rate of the seconds watch has been altered during their continuance. Whenever all these precautions have been attended to, it may be concluded that the movements of the watches have been as regular as possible, and expected that the longitude will be found within the limits of that precision which the safety of navigation requires.

93. When the absolute gain or loss of a watch with regard to mean time at any place is known, and its diurnal variation, it is very easy to deduce its absolute gain or loss in reference to the same species of time at the same place, for any period subsequent to that at which the watch was regulated. Suppose that a series of observations on the sun's altitude had been made at sea, for obtaining the longitude by a marine chronometer; the absolute gain or loss of the chronometer, with respect to mean time at the place where it was regulated, may be calculated by the following rules.

If the chronometer was before mean time, and it is known to gain a certain number of seconds every day; add to the absolute gain the product of this number of seconds

by the number of days and parts of a day between the two epochs of the observations; if, on the contrary, the diurnal variation is a loss, this product must be subtracted from the absolute gain observed at the place where the chronometer was regulated, and the remainder will be the absolute gain corresponding to the proposed epoch.

In the case in which the chronometer is too slow, there must be added to its loss, the product of its diurnal loss multiplied by the days and fraction of a day elapsed between the two epochs of the observations: on the contrary, the product of the diurnal gain by the number of days and parts must be subtracted from the absolute loss; and we shall have the absolute loss of the chronometer, with respect to mean time, at the place where it was regulated, for the required time.

The absolute gain must then be subtracted from the mean time corresponding to the mean altitude, or else the absolute loss added to the same time; and there will be obtained the mean time that should be reckoned at the place where the chronometer was regulated, at the instant of observing the horary angle. Add to or subtract (art. 87) from this, the equation of time, and the sum or remainder will be the true time corresponding to the same moment. The calculation of the horary angle will give the true time at the vessel; the difference of these two times will be equal to the difference of longitude between the place of the vessel and that where the chronometer was regulated; which may be reduced into degrees by the known rules. The vessel will be to the east of the place, if the time resulting from the calculation of the horary angle is the greater; and on the west of it, when this time is the less. Then add the difference of longitude to that of the place where the chronometer was regulated, or subtract it from it, according as the vessel is on the east or west of that meridian; and the longitude of the vessel will be obtained, reckoned from the first meridian. When the

chronometer has been regulated for the first meridian, the difference between the true time obtained by the chronometer, and that resulting from the calculation of the horary angle, gives the longitude of the vessel directly.

EXAMPLE.

On the 15th of April 1793, being in South latitude 19 51′ 20″, and 167° 40′ East longitude, by account; that is, 8 days after the last observations made at Tongataboo for regulating the marine chronometer (see the ex. art. 88); the altitudes of the sun's lower limb was observed, at about 2^h 46′ after noon, in order to obtain the longitude by the chronometer. The elevation of the eye above the surface of the sea was 20$\frac{1}{6}$ feet. The longitude of the harbour of Tongataboo is 177 33′ 14″ West.

It would be useless to enter into the detail of the calculation of this example; all the given quantities that should be employed will be found in the following specimen, in the order the most convenient and proper for facilitating the operations; this will be sufficient to show the manner in which all other calculations of the same kind should be performed.

April 15*th*, 1793

Latitude by account, S - - -		19°	51′	20
Longitude by account, E. - - -		167	40	0
Sum of the observed alts. of the ⊙. -		233	56	40
Mean altitude of the ⊙. - - -		38	59	26
Elevation of the eye 20$\frac{1}{6}$ feet.	Depression	—	4	24
	Remainder - -	38	55	2
	Semi-diameter of the ⊙. -	+	15	57
		39	10	59
	Refraction — parallax -	—	1	6
True altitude of the ⊙'s centre -		39	9	53

Watch before mean time at Tongataboo, the 7th of April, at 7^h 53′. (See the Ex. to art. 88) - - - - - -	0^h	1′	20″·93
Daily advance + 5″·24; in 8·3 days - -		+ 43	49
Watch before mean time, at Tongataboo, 15th April - - - - - -	0	2	4·42
Time at the first meridian, the 14th April	14	38	0
Declination of the sun, N. - - -	9°	53′	15″
Distance from the elevated pole - -	99	53	15

Longitude of the island of Panghaimodoo, in the harbour of Tongataboo, the place where the chronometer was regulated,

	177°	33′	14″	
In time -	11^h	50′	13″	
Times by the chronometer - -	0	23	19	
	0	23	57	
	0	24	42	
	0	25	21	
	0	26	58	
	0	27	42	
		151	59	
Mean time -	0	25	19	83
Time by the chronometer, at the moment of comparison. *Add* - -	3	38	8	17
Sum -	4	3	28	
Time by the seconds watch *Subtract* -	0	15	0	
Time by the marine chronometer -	3	48	28	
Before mean time at Tongataboo *Subtract*	0	2	4	·42
Mean time at Tongataboo - - -	3	46	23	58
Mean time at true noon. *Subtract* -	11	59	56	47
True time at Tongataboo - - -	3	46	27	11

True alt. of the ⊙	39° 9′ 50″		
Latitude - -	19 51 20	Com. cos. -	0·0206172
Polar distance -	99 53 10	Com. sin. -	0·0064972
Sum - - -	158 54 20		
Half sum - -	79 27 10	- - cos. -	9·2625599
Half sum—alt. of ⊙	40 17 20	- - sin. -	9·8106638
		Sum - - - -	19.1063381
		Half sum - - sin.	9.5531690
		Half horary angle	22° 56′ 10″
		Multiplying by - - - -	8
In the morning, take the comp. to 12 hours -	True time at the vessel		2h 47′ 29″ 20‴
	True time at Tongataboo -		3 46 27 7
When the time at the vessel is the greater, it is to the East -	The vessel is now to the West of Tongataboo		0 58 57 47
	In degrees -		14° 44′ 27″
	Longitude of Tongataboo W.		177 33 14
Subtract from 360°, the longitude never exceeds 180	Longitude of the vessel West -		192 17 41
	LONGITUDE of the vessel, *East*		167 42 19

91 It ought to be remarked, that in order to obtain the absolute gain or loss of the chronometer for every day, with respect to mean time, at the place where it was regulated, the diurnal variation of the chronometer must be successively either added to or subtracted from, the gain or loss found from the observations. The quantity which should be added or subtracted daily is therefore the sum of all the diurnal variations of the preceding days From the moment that the movement of the chronometer experiences a change, the diurnal variation employed is affected with an error, which has a daily influence, equal to its whole value, on the longi-

tude derived from the time kept by the chronometer. At the end of a certain time, the errors of longitude are equal to the sum of all the errors in longitude observed during the preceding days. It follows from this, that marine chronometers can only give with precision the differences of longitude of the places where the observations have been made at epochs very near to each other. For this reason, they are employed with the greatest success in the construction of marine charts; in which case, they show the relative positions in longitude of all the places inserted in these charts. But when they are used for the common purposes of navigation; that is, for calculating the distance of the port to which the vessel is sailing, it would be imprudent to rely wholly upon them; and it is necessary to compare the longitudes obtained by the chronometer with those deduced from observations on the distances of the moon from the sun and the stars: these last ought always to be within the limits of a known precision, and are very proper for ascertaining whether chronometers preserve the same regularity in their movements, and whether the longitudes obtained by them can be depended upon, without exposing the safety of the vessel.

95. The method of obtaining longitude by marine chronometers, is perhaps, that which has contributed the most to the progress of hydrography and geography. To be convinced of this, it is only necessary to glance at the astronomical observations published in a series of relations of long voyages, both French and English, that have been made since the first voyage of Captain Cook: it will then be seen what advantage has been derived from them. But it cannot be concealed that those chronometers, of such generally acknowledged utility, may suddenly experience derangements, and without our being able to assign the cause, the consequences of which may prove fatal, if the other means which nautical astronomy furnishes for determining

the position of the vessel, be neglected. It is therefore impossible, and it would even be dangerous to endeavour to estimate the errors with which the longitudes from chronometers may be affected at the end of a certain time. The regularity of most of the chronometers now in use only serves to confirm their general utility: there ought, however, to be no hesitation in saying, that we cannot compare a watch with itself. Though all probabilities are in favour of chronometers that have been proved, we dare not yet assert that a chronometer, the rate of which has always been regular, will preserve that regularity of motion, which the greater or less humidity of the atmosphere, or different degrees of extreme temperature, may cause it to lose. And, therefore, the necessity of verifying the longitudes obtained by means of chronometers, by observations of the distances of the moon from the sun and the stars, cannot be too much insisted upon.

Marine chronometers whose rates have been best ascertained, have generally given the longitude to about half a degree, at the end of a voyage of three months. The chronometer, *No.* 14, of M. *Louis Berthoud*, which was used during the voyage of Rear-Admiral *D'Entrecasteaux*, has always given the longitude of the vessel to about a quarter of a degree, even at the termination of a voyage of more than three months. But this astonishing precision, which ought in reality to be attributed in a great measure to the regularity of its movements, may also have arisen from some of the errors in longitude having been of such a nature as to compensate others. In general, good marine chronometers, like those that have been mentioned, preserve a very regular rate during a period of about two years, after being taken from the hands of the watch-maker; but at the end of that time the oil begins to thicken, and wants renewing; then the movement changes successively by a small quantity, and generally tends towards acceleration.

Means of correcting the Longitudes obtained by Marine Chronometers.

96. When marine chronometers have been used for directing the course of a vessel and bringing it to a coast, the observations that may be made during the stay of the ship at that place, cannot be of any other utility than that of ascertaining the diurnal variation of the chronometer, which should be employed in finding the longitude during the following passage. But if the geographical position of some of the places at which she has touched has been determined, then the diurnal variation observed during a succeeding stay in port, may serve, in certain cases, to correct the longitudes of these places, and greatly to increase their accuracy. These corrections become altogether indispensable when the diurnal variation has changed considerably in the interval between the observations that have been made for regulating the chronometer. The method of calculating these corrections shall now be explained

97 Suppose it were known from astronomical observations, that the diurnal variation of a marine chronometer was not the same at any place as it was at the port from which the ship sailed. Calculate, first, the difference of longitude which there ought to be between the port of departure and that arrived at, with the diurnal variation observed immediately before the commencement of the voyage; then take half the sum of the two diurnal variations, and calculate the same difference of longitude with this mean variation. The result of the second calculation will be the corrected difference of longitude; and the quantity which it is greater or less than the former will be the correction that ought to be applied to the first difference of longi-

time: this difference should be used in finding all the corrections of the other longitudes observed during the same voyage. It should be observed that, if this correction place the port arrived at to the east or west of the positions assigned it by the calculation made with the diurnal variation of the port of departure, all the other corrections ought to be employed in the same sense.

Search, in Table XI, opposite the number which expresses that of the days elapsed since the chronometer was first regulated, for another number, entitled, *Multiple of the Second Difference*; then, by means of logarithms, divide the correction of the longitude at the place arrived at by this number, and it will give the second difference of the corrections of all the longitudes observed during the voyage. The correction of other longitudes will be found by multiplying this second difference by the multiple corresponding to the number of days elapsed from the time the chronometer was regulated, to the time when the longitude, for which the correction is to be calculated, was observed. These rules shall be illustrated by an example.

EXAMPLE.

It has been found in the Ex. art. 88, that the diurnal gain of the chronometer, *No.* 14, at Tongataboo, was + 5″·21; the 6th of April 1793, at 19h 50′ 31″·44, the last day of the observations, the chronometer was before mean time at Tongataboo, 0 1′ 20″ 93. Having sailed from the last place to the harbour of Ballada, and made a fresh series of observations for ascertaining the diurnal variation of the same chronometer; it was found + 8″·56. The 22d of April, the first day of the observations at Ballada, the chronometer was before mean time at this port 1h 24′ 23″·71.

Diurnal variation found at Tongataboo -	+ 5″·24
Diurnal variation of Ballada - - -	+ 8″·56
Sum -	13″·80
Half sum. Mean diurnal variation -	+ 6·9
Difference in longitude between the harbour of Tongataboo and that of Ballada, by the first diurnal variation, + 5″·24 - - - -	20° 24′ 34″
Difference in longitude by the mean variation	20 17 55
The difference of longitude ought to be diminished, and the harbour of Ballada to be more to the east by - - -	0 6′ 39″

Required the correction of the longitude observed on the 17th of April, at 7^h 34′.

Correction of the longitude of Ballada, after 16 days, 6′ 39″, or 399″	log. -	2·60097
Multiple from Table XI, corresponding to 16 days - - 136	Comp. log.	7·86646
	Constant log.	0·46743
From the 6th of April to the 17th, 11 days - - - -	Multiple 66 log.	1·81954
	Sum -	2.28697
Correction of longitude on the 17th of April	-	3′ 14″

The correction of the longitude on the 17th, ought to cause the situation of the place of observation to be more to the east, because that Ballada should also be to the east of the position calculated from the diurnal variation found at Tongataboo.

The correction of longitude may be calculated for other days of the same voyage, by adding to the constant logarithm, the logarithm of the multiple from Table XI, which answers to the number of days elapsed from the 6th of

April to the time when the longitude to be corrected was observed.

98. This correction of longitudes observed at the end of a long voyage is indispensable, during which the diurnal variation has experienced changes. The corrections of the longitudes near the commencement of the voyage will always be very small, and consequently less necessary; but those observed at the middle of a long voyage must be very uncertain, and the positions fixed by them but little susceptible of correction, except from the results obtained from distances. Suppose that after a voyage of three months, it was ascertained that the diurnal variation of the chronometer had changed several seconds; then the corrected longitudes of the first and last month, may be considered as approaching near the true longitudes, but those of the second month must always be regarded as uncertain.

CHAPTER VI.

On finding the Longitude by the Distances of the Moon from the Sun and the Stars.

99. The method of the distances of the moon from the sun and the stars is generally allowed to be the best of all those that can be employed for finding the longitude at sea. It has already been said, that it ought to be used for verifying the longitudes obtained by the use of marine chronometers, and that there is not any other means of establishing the regularity of their movements: it may therefore be regarded as that which has given us the solution of the problem of longitudes, with which all the learned astronomers of Europe were so long occupied. The accuracy of the results obtained by the method of distances, depends upon the precision with which the position that the moon ought to occupy in the heavens at any instant can be ascertained. The slow progress which this method at first made should be attributed to the complicated nature of the theory of the lunar motions, and the difficulties which astronomers had always to encounter when they wished to calculate her inequalities. *Tobias Mayer*, by the assistance of this theory and observations, constructed tables which have served to predict the moon's place with a degree of accuracy sufficient for the safety of navigation. Since their publication, the distances of the moon from the sun and some of the princi-

pal stars have been inserted in all the Ephemerides; and navigators, having been made acquainted with the utility of observations of these distances, began to practise them. But, notwithstanding the great care and pains that were taken to perfect these tables, their precision still left something to be desired. In short, M. *Laplace*, in submitting the lunar motions to the calculations of analysis, discovered irregularities in them which, till then, had escaped all investigation, and obtained the means of giving to the method of distances the greatest degree of precision of which it is susceptible. With the assistance of *Delambre's* solar tables, and the tables of the moon calculated by M. *Bürg*, from the theory of *Laplace*, both of which have been published by the Bureau des Longitudes, it is possible to predict the distances, and to obtain the longitudes, with a degree of precision which we should not have dared to flatter ourselves with being able to attain, when this method was first brought into practice. The perfection which artists have given to sextants, and the invention of the reflecting circle, have also added great advantages; in the actual state of things, navigators can no longer dispense with employing observations which may make known their position on the globe within some leagues, and afford them the power of obtaining from marine chronometers whatever assistance they are capable of affording.

100. The object of employing this method is to ascertain the true distance of the moon and the sun or a star, at any given instant; for the purpose of deducing from it the time which, at that instant, is reckoned at the first meridian; the time at the place which corresponds to the same instant is obtained from the altitude of the sun; these times being thus determined, their difference reduced into degrees, is the longitude required.

101. It has been shown that the altitudes of the heavenly

bodies appear greater than they ought to be from the effects of celestial refraction; the altitudes of the sun and moon appear less on account of their parallax. From the union of these two causes, it follows, that the observed distances are not equal to the true ones; they must therefore be corrected for the effects of refraction and parallax, when it is wished to obtain the true distance, from which the time at the first meridian may be directly concluded. It has been stated, art. 29, that the quantity by which the apparent altitudes of the heavenly bodies are too great from the effects of refraction, and in art. 33, that the quantity by which they appear too little on account of parallax, depend upon the apparent altitudes of these bodies; thus, to know the absolute values of these quantities, the altitudes of the two bodies must be measured at the same moment as their distance is observed, or else the method of obtaining these altitudes from calculation must be found. It is this which shall first be explained. We shall then treat of calculating the true distance; but the object of this treatise being to perform all the calculations of nautical astronomy, with the sole assistance of the Nautical Almanac, or the Connaissance des Tems, and a table of logarithms to seven places, we shall content ourselves with giving the method which is generally known by the name of *Borda*'s: it is the shortest that can be employed, when tables of common logarithms only are used.

On the Methods of obtaining the Altitudes of the heavenly Bodies, the Distances of which have been observed.

102. When neither a marine chronometer nor a seconds watch is employed, the observation of distances requires three observers: while one of them measures the distance, the other two should take the altitudes; by this means,

the distance and the two corresponding altitudes are obtained by three simultaneous observations. But the distance is that which it is of the greatest importance to obtain with precision, because the errors by which it may be affected will have a greater influence on the result than the errors in the altitudes; each of the observers who takes the altitudes must therefore bring the body he is observing to the horizon, and take care to follow its movements with the repelling screw of the instrument, so that one of its edges may always be in contact with that circle. At the instant that he who observes the distance has brought the limb of the sun or a star to coincide with the limb of the moon, he informs his two coöperators, and they reckon on their instruments the two simultaneous altitudes. The two altitudes and the distance are written down separately when this last is taken with a sextant. Four observations must be made in this manner, but whenever it can be done, six should be taken. When the distance is observed with a reflecting circle, the arc passed over by the index is read off only at the end of the last observation, and it will give directly the sum of the observed distances. The sum of the altitudes of each of the bodies and that of the distances being divided by the number of observations, will give the mean altitudes and the mean corresponding distance.

Example.

The 16th of June 1793, at $1\frac{1}{2}$ hour after noon, being in South latitude 10° 16′ 40″, and East longitude 149 by account, six distances of the nearest limbs of the sun and moon were observed, and at the same instants, six altitudes of the lower limb of the sun, and six of the upper limb of the moon, were taken.

	Altitudes of the ☉.		Altitudes of the ☾.
	48° 49′		26° 56′
	48 28		27 27
	48 18		27 51
	48 6		28 8
	47 57		28 22
	47 47		28 37
Sum - - -	289° 25′	Sum - -	167° 21′
Sixth - - -	48 14 10″	Obs. alt. ☾.	27° 53′ 30
Rect. of the inst.	+ 2 0		
Obs. altitude ☉.	48° 16′ 10″		

Sum of the distances ☉ ☾. - - - 500° 40′ 40″
Observed distance ☉ ☾. - - - 83° 26′ 46″

103. The difficulty of exactly following the motion of the heavenly bodies with the repelling screw of the instrument, renders the altitudes taken in this manner less susceptible of precision, than in those observations where the observer employs the altitude of a celestial object only when he is certain of having made a good observation. The accuracy of the altitudes cannot be answered for at least within 2′, and sometimes the errors amount to 3′. These errors can never have a great influence upon the true distance; but as the time at the place of observation must be calculated with the altitude of the sun, they may have a sensible effect upon the longitude: this is the reason that the sun's altitude should always be taken by an observer well experienced in this kind of observations, and with a well rectified instrument.

104. When a marine chronometer, or simply a seconds watch is possessed, the following method will always be preferable. Take an account of the hour, minute and second, at which each observation of the distance is made; then a mean distance corresponding to the mean time may be obtained. A few instants before these observations are

to be made, take one or more altitudes of the heavenly bodies of which the distance is to be observed, and also an account of the time answering to each of these altitudes. Immediately after observing the distances, take the altitudes of the same two bodies again; the difference of the altitudes observed before and after the distance will give the movement in altitude of each body in the interval of the observations, which is equal to the difference of the times corresponding to these altitudes. Then take the difference between the time of the first observation of the altitude and the mean time corresponding to the mean distance, and it will give a second interval; next calculate, by proportion, the movement in altitude which corresponds to it. Add this last to the first observed altitude when the altitude is increasing, but subtract it when it is decreasing, and the altitude corresponding to the mean distance will be obtained. These rules shall be illustrated by an example.

EXAMPLE.

On the 17th of June 1793, at $4^h\ 32'$ in the evening, being in South latitude $9°\ 57'$, and $148°\ 50'$ of East longitude, the following observations of the distance between the sun and the moon were taken, and of the altitudes of these two bodies, with a seconds watch, the elevation of the eye being $20\frac{1}{4}$ feet.

Time of the Distances.		
$1^h\ 48'\ 55''$		
49 55	Sum of the distances ☉ ☾.	$571°\ 2'\ 0''$
51 2		
52 34		
53 53	Mean distance -	$95°\ 10'\ 20''$
54 51		
Sum - $311'\ 10''$		
Mean time $1^h\ 51'\ 51''.6$		

	Times.		Altitudes ☉.
1st observation -	1^h 49′ 25″	- -	32° 21′ 30″
2nd observation	1 54 22	- -	31 22
1st interval -	0^h 4′ 57″	Difference	0° 59′ 30″
Time of the first observation		- -	1^h 49′ 25″
Time of observing the distance		- -	1 51 51
2nd interval - - - - - - -			0^h 2′ 26″

1st *inter.* 4′ 57″ : 2d *inter.* 2′ 26″ :: 1st *chan. in alt.* 59′ 30″ : x.

1st change in altitude -	59′ 30″	- - log. -	3·55267
1st interval - - - - -	4 57	Com. log.	7·52724
2nd interval - - - - -	2 26	- - log.	2.16435
		log. x =	3.24426
x, or 2nd change in altitude		- - -	0° 29′ 15″
1st altitude ☉		- - - -	32 21 30
The ☉ *descends.* *Difference.*		Altitude ☉.	31° 52′ 15″

	Times.		Altitudes ☾.
1st observation	1^h 51′ 2″	- - -	40° 45′
2nd observation	1 52 34	- - -	41 5
	0^h 1′ 32″	Difference -	0° 20′
Time of the first observation		- -	1^h 51′ 2″
Time of the distance		- - -	1 51 51
2nd interval - - - - -			0^h 0′ 49″

1*st inter.* 1′ 32″ : 2*d inter.* 0′ 49″ :: 1*st chan. in alt.* 0° 20′ : x.

1st change in altitude -	0° 20′	- - log. -	3·07918
1st interval - - - - -	1 32	Com. log. -	8·03621
2nd interval - - - - -	0 49	- - log. -	1·69020
		log. - x. =	2·80559
x, or the second change in altitude		- -	0° 10′ 39″
1st altitude of the moon		- - -	40 45 0
The ☾ *ascends.* *Sum.*		Altitude of ☾ -	40° 55′ 39″

105. The observations may be made in this manner by a single observer; but it would be advantageous if he who measures the distances had an assistant to take the altitudes, and especially those of the sun. These last have the inconvenience of greatly fatiguing the sight, when the sun is not very elevated; then his reflection often renders the horizon so bright, that his light must be weakened by means of a coloured glass. The altitudes may be taken 7′ or 8′ before and after the observation of the distance; but it must be remarked, that the altitudes corresponding to the distance will be susceptible of much greater accuracy when they are taken nearer to the instant at which that distance is observed. It is also necessary that the mean time corresponding to the mean distance, should be between the times corresponding to the two observed altitudes. Whenever all these circumstances have been attended to, the altitudes calculated by proportional parts will have a precision nearly equal to those which have been directly obtained from observation.

106. When the visual horizon is limited by land in the direction of one of the heavenly bodies of which the distance has been taken, and a seconds watch was used, its gain or loss, with regard to mean time, must be ascertained by observing the sun's altitude when he answers to a point of the horizon where the sea appears clear. Then the altitude of the heavenly body may be calculated by the rules given in arts. 79 and 80.

107. The difficulty experienced in observing the altitudes of the stars, and even those of the moon during the night, has been mentioned. Errors of 5′ or 6′, of which they are susceptible, will not have a great influence upon the true distance of the moon from a star; thus, if preferred, the altitudes for correcting the distance may be observed. But, as an error of 5′ or 6′ may, in some cases, occasion an error

in the horary angle of 30″ of time, and even sometimes more, the time at the place should never be calculated with the altitude of a star. To supply its place, the gain or loss of the watch by which the time corresponding to the distances should be calculated from an observation of the sun's altitude, made either on the evening which precedes, or the morning that follows the time at which the distance is taken; and then, by means of the way made in longitude, the time at the place where the distances were observed should be found. In this case, the observations of the altitudes of the two bodies may be dispensed with; for they may be obtained with much greater accuracy from calculation than by observation. This method was recommended by *Borda* in his treatise on the reflecting circle; and it is that which ought to be practised. Articles 79 and 80, contain circumstantial details relative to the operations which should be performed for calculating the altitudes of the heavenly bodies.

Calculation of the true Distance, and of the Time at the first Meridian.

108. When the altitudes corresponding to the mean distance have been obtained by the methods already explained, the true distance and the time at the first meridian must be calculated by the following rules. An example shall first be given for the case in which the altitudes have been procured directly from observation; then the method that should be followed when the true altitudes of the heavenly bodies, corresponding to the distance, have been obtained by calculation, shall be explained in a second example.

109. First, calculate the time at the first meridian corresponding to the instant of the observations, by means of the estimated or true time at the place, and the longitude by account; then take from the Nautical Almanac, the semi-

diameters of the sun and moon at that instant. Find, in Table II, the augmentation of the moon's semi-diameter answering to her altitude, and it will give her apparent semi-diameter. Then find her equatorial parallax for the moment of the observation, and Table III will show, by means of the latitude, the quantity which this parallax ought to be diminished in order to obtain the parallax at the place of observation. These given quantities will serve for ascertaining the apparent distance between the centres of the sun and moon, or the apparent distance of a star from the centre of the moon, as well as the apparent and true altitudes of the centres of these two bodies.

110. When distances of the sun and moon are taken, the observation always gives the distance of their nearest limbs; then their semi-diameters must be added to the observed distance. If the distance between the moon and a star be taken, it gives the distance between the star and the enlightened limb of the moon, which is sometimes the nearest and sometimes the most distant; it must therefore be observed, in making the observation, which limb has been used. When the nearest limb has been observed, the apparent semi-diameter of the moon must be added to the observed distance, according to the preceding rule; but if the distance between the star and the most distant limb of the moon was observed, the moon's apparent semi-diameter must be subtracted from the observed distance. The distance thus found is called the *apparent distance.*

111. Then, correct the observed altitudes for the depression of the horizon, and the semi-diameter of either the sun or the moon; and the results will be the apparent altitudes of each of these bodies. Next find the refractions and parallaxes which answer to these altitudes, and when corrected for these, the true altitudes will be obtained. It is unnecessary to enter into greater detail relative to these correc-

tions, since the rules which should be followed have been explained in the second chapter. Those who are not familiar with these operations, may have recourse to what has there been said on the subject. The refractions of Table V, and those of Table VIII, ought always to be corrected according to the elevation of the mercury in the barometer and thermometer, whenever the altitude of either of the two bodies is less than 40°.

112. When the true altitude of the moon's centre has been obtained by calculation, search first in Table VIII, with this altitude instead of the apparent altitude, for an approximative number, which will sometimes differ from that which ought to express the true parallax of the altitude less refraction, by nearly a minute. With this number calculate a first apparent altitude, and then search in the same table the number that corresponds to it; this will be the parallax in altitude less refraction, which is to be subtracted from the true altitude resulting from the calculation, in order to obtain the apparent altitude of the moon's centre.

113. The apparent distance of the two bodies, their apparent altitudes, and their true altitudes, are the five data with which the true distance is to be calculated. The following are the necessary rules.

Write, in the following order; first, the apparent distance of the two heavenly bodies, then the apparent altitude of the sun or the star, and lastly, the apparent altitude of the moon; add these three quantities together, and take half their sum. The apparent distance and the half-sum being thus known, subtract the less of these quantities from the greater. Below this remainder, write the true altitude of the sun or the star, and afterwards that of the moon; add these two altitudes together, and take half their sum. When this preparation for the calculation has been made, look successively in the logarithm tables for the arithmetical

complements of the logarithm cosines of the apparent altitudes; find also in the same manner, the logarithm cosines of the half sum of these altitudes, and of the apparent distance, as well as the logarithm cosine of their half difference, and write these two logarithms below the two arithmetical complements before found: then write, also below the last, the logarithm cosines of the true altitudes. Add together the two complements and the four logarithms, and take half the sum thus obtained; from this half sum subtract the logarithm cosine of the half sum of the true altitudes, and the remainder will be the logarithm sine of an auxiliary angle. Place the logarithm cosine of this auxiliary angle below the logarithm cosine of half the sum of the true altitudes; then the sum of these last two logarithms, will be the logarithm sine of half the true distance. Double of the corresponding arc will be the distance corrected for the effects of refraction and parallax, or the true distance with which the time at the first meridian ought to be calculated.

When the true distance has been calculated by this method, it may happen that the sum of the apparent distance and the apparent altitudes may be greater than 180°; then it will not be necessary to continue the calculation, and the apparent distance may be corrected, by first taking the difference of the correction of the moon's altitude and that of the altitude of the sun or star, and then subtracting this difference from the apparent distance of the two bodies.

114. Search, in the Nautical Almanac, for the two distances between which the distance resulting from the calculation is found; write these below each other; then take their difference, which will be the change in the distance answering to three hours. Also take the difference between the calculated distance and the first in the tables; and having the change which answers to 3 hours, the interval of time answering to this last difference may be found by proportion.

This second interval should be calculated by logarithms. It must always be added to the time of the first distance in the tables, and the sum will be the required time at the first meridian.

All the operations which are to be performed, either in procuring the apparent distance and altitudes, or for obtaining the true altitudes; or, lastly, for calculating the true distance from which the time at the first meridian and the longitude are found, shall now be explained: the example in art. 102 may be resumed, in which the altitudes and distances have been obtained by simultaneous observations.

EXAMPLE.

On the 16th of June 1793, at about one hour and a half after noon, being in South latitude 10° 16′ 40″, and 149° of East longitude, by account, six observations of the distance between the sun and moon were taken, and six simultaneous altitudes of each of these two bodies. The mean distance of their nearest edges was found to be 83° 26′ 46″; the mean altitude of the sun's lower limb was 48° 16′ 10″; and that of the moon's upper limb 27° 53′ 30″.

It is found, by means of the estimated time at the place of observation and the longitude, by account, that the estimated time at the first meridian which corresponds to the observation of the distance, is the 15th of June at 15h 34′. The semi-diameter of the sun, taken from the Nautical Almanac, was at that instant 15′ 46″. The semi-diameter of the moon was 14′ 54″; the small Table II shows that, at 27° 53′ or 28° of altitude, that there must be added 7″ to have the apparent diameter which will then be 15′ 1″: these last quantities should be employed in obtaining the apparent distance and apparent altitudes of the centres of the sun and moon. The equatorial parallax is 54′ 41″, but at 10° of

altitude it must be diminished by [illegible]; hence there must be used in the calculation only 54′ 40″.

When these first elements are known, the apparent distance must be calculated. The calculations of all the quantities which are to be obtained in order to find the true distance, and from it the longitude, shall now be successively given; but, to render the proceeding still clearer, all these quantities have been collected into a table which is subjoined to the end of the calculation of the time at the place of observation; and will serve as a guide to those who wish to exercise themselves in calculating the longitude from observed distances.

Observed distance between the limbs of the ⊙ ☾	83° 26′ 46″
Semi-diameter of the ⊙. - - - -	+ 15 46
Semi-diameter of the ☾. - - - -	+ 15 1
Apparent distance of the centres of the ⊙ ☾.	83° 57′ 33″

The observed altitudes of the two heavenly bodies are to be corrected for the depression of the horizon and their semi-diameters, and the apparent altitudes of their centres will be obtained; then these altitudes must be corrected for the effects of refraction and parallax, by means of the numbers found in Tables V and VIII, which will give the true altitudes. It is essential to attend to the variations which these last numbers experience relatively to the height of the mercury in the barometer and thermometer, as will be shown.

Observed altitude of the ⊙. - - -		48° 16′ 10″
Elevation of the eye - 20¼ feet. Depression		− 4 24
		48 11 46
Semi-diameter of the ⊙. - - - -		+ 15 46
Apparent altitude of the ⊙.		48 27 32
Refraction — Parallax - -	0′ 45″	
Thermometer + 78·98 - -	− 2	− 0 43
Barometer - 29·988 in. - -	0	
True altitude of the ⊙. - - - -		48° 26′ 49″

Observed altitude of the ☾ - -		27° [illegible] 30"
Elevation of the eye 20½ ft. Depression		— 4 24
		27° 49' [illegible]
Semi-diameter of the ☾ - - -		+ 15 1
		27° 34' 5"
Parallax — Refraction - -	46' 38"	
Thermometer 78·98 - - - -	+ 5	- - 46 43
Barometer - 29·99 in. - - -	0	
True altitude of the ☾ - - - -		28° 20' 48"

In calculating the distance, the proportional parts must be taken, in order to have the logarithms corresponding to the seconds of a degree. This however may be, in a great measure avoided, if from the apparent distance there be subtracted such a number of seconds as will make the remainder contain only even tens of seconds. For example, in this case, 83° 57' 30" may be used instead of 83° 57' 33"; but the 3" that have been subtracted are to be written above the distance with the sign +, which indicates that they ought to be added to the true distance obtained by the calculation. Subtract from the apparent altitudes in the same manner, the number of seconds necessary to make them contain only tens of seconds, or else add this number to complete them. These small changes should always be made in such a manner that the tens of seconds of the sum of the distance and of the apparent altitudes may be an even number; then the half sum, and the difference of that half sum and the distance, as well as the apparent altitudes, will contain only tens of seconds; we shall therefore be able to take two arithmetical complements and two logarithms, without being obliged to calculate the proportional parts.

It is important not to neglect, in writing down the true altitudes, to add to, or subtract from them, the same number of seconds that has previously been added to, or subtracted from the apparent altitudes, in order that the difference of

the true and apparent altitudes of each body may remain always the same. It is on the value of this difference that the value of the reduction of the apparent distance, or the difference of this and the true distance, in a great measure depends. In this example, we have subtracted 2″ from the sun's apparent altitude, they must therefore be likewise taken from his true altitude, and then 48° 26′ 47″ is to be written instead of 48° 26′ 49″. There has also been 5″ subtracted from the apparent altitude of the moon, and therefore, in the calculation of her true altitude, only 28° 20′ 43″ must be used instead of 28° [illegible] 48″.

	+ [illegible]				
Appar. Dist. ☉ ☾	83 [illegible]				
Appar. Alt. ☉	48 27 [illegible]	com. cos.	0·1783787		
Appar. alt. ☾	27 34 0	com. cos.	0·0523345		
Sum	159° 59′ 0″				
Half sum	79 59 30	cos.	9·2400283		
Dist. [illegible]	3 58 0	cos.	9·9989584		
True alt. ☉	48 26 [illegible]	cos.	9·8217234		
True alt. ☾	28 [illegible] 43	cos.	9·9[illegible]		
Sum	70° 47′ 30″	Sum	39·2359565		
		½ Sum	19·61797[illegible]	9·7238069 sine auxiliary angle.	
Half sum	38° 23′ 45″	cos	9·8941713	31° 58′ 0″ auxiliary angle.	
Auxiliary angle		cos.	9·9285783		
Sum		sin.	9·8227496		
Half the distance			41° 40′ 26″		
Double, Distance			83° 20′ 52″		
Add the seconds neglected			+ 3	1st inter. 3h	log. 4·0334[illegible]
TRUE DISTANCE			83° 20′ 55″	1st diff. 0° 18′ 46″	log. [illegible]05154
Distances in the Tables at 15h			83 2 9	2nd. diff. [illegible] [illegible]2′ 24″	C. log. 6·30592
Distances in the Tables at [illegible]			84 [illegible] [illegible]	Sum	3·3908[illegible]
Time of the first tabular distance			15h 0′ 0″	2d interval	0h 41′ 0″
2d interval			0 [illegible] 0		
Time at the first meridian			15h 41′ 0″		

115. The distance which results from the calculation is 83° 20′ 52″; the 3″, which were neglected before beginning

the calculation, must be added to it, and the true distance will be 83° 20′ 55″. The two distances in the Connaissance des Tems, between which this calculated distance is found, are 83° 2′ 9″, and 83° 24′ 35″. The first of these takes place at 15^h, and the second at 18^h. The interval by which they are separated, and which is called the first interval, is 3h. Write these distances, and the hours which correspond to them, under the true distance, as above; then take the difference of the true distance and the first tabular distance, which will give a first difference; this is to be placed on the right of the distance to which it corresponds. Also take the difference of the two tabular distances and it will be the second difference, which is the change in distance in 3^h, or in the first interval. These quantities are to be used in calculating the second interval, or that which answers to the difference between the calculated distance and the first tabular distance, which has been called the first difference. Make this proportion; the second difference is to the first interval of 3^h, as the first difference of 18′ 46″ is to the second interval, which must always be added to the time of the first distance to obtain the hour at the first meridian. The fourth term of this proportion should be calculated by logarithms; thus, in order to have the logarithm of the second interval, add the constant logarithm of 3^h, that of the first difference, and the arithmetical complement of the second difference together.

Calculation of the Time at the Place of Observation.

116. The method which should be followed in finding the time at the place depends upon the manner in which the altitudes of the two heavenly bodies have been obtained. When they have been taken, as well as the distance, by simultaneous observations, and the time of these observations

could not be reckoned by the watch, the horary angle of the sun must be calculated by means of his observed altitudes, by the rules in art. 75; then the time at the place may be deduced from it. The difference which exists between this time and the time at the first meridian, that has been calculated from the true distance, reduced into degrees, will be the longitude of the vessel. When the time at the place is greater than that at the first meridian, this longitude is east; but when it is less, the vessel is to the west of the first meridian, and its longitude is west.

117. Now to find what time at the vessel corresponds with the time at the first meridian, which has been previously calculated. Take first, in the Connaissance des Tems, or the Nautical Almanac, the sun's declination which answers to the calculated time at the first meridian; in this case it is 23° 22′ 47″ North, but the latitude is 10° 16′ 40″ South: the distance of the elevated pole will therefore be 113° 22′ 47″. Proceed with these quantities and the true altitude of the sun to calculate the horary angle. It should be remarked, that the altitude increased or diminished by a certain number of seconds, must not be employed in the calculation, but that which is immediately deduced from the observed altitude. Thus, in the present example, the altitude of the sun which should be employed in calculating the time, is 48° 26′ 49″, instead of 48° 26′ 47″.

True altitude ☉.	48°	26′	49″			
Latitude, South	10	16	40	-	comp. cos.	0·0070251
Polar distance ☉	113	22	47	-	comp. sin.	0·0372070
Sum -	172°	6′	16″			
Half sum - -	86	3	8	- - -	cos.	8·8378864
½ Sum — altitude	37	36	19	- - -	sin.	9·7854851
	Sum			- - -		18·6676036

	Half sum - - -	[illegible]9018
	Half of the horary angle -	12° [illegible] $18''$
	Multiplying by - - -	[illegible]
(*Add* 24^{h}).	Time of the place -	$1^{h}\ 39'\ 38''\ 24'''$
	Time at the first merid.	$15\ \ 41\ \ 0\ \ 0$
	Difference - -	$9^{h}\ 58'\ 38''\ 24'''$
	LONGITUDE, East -	$149^{\circ}\ 39'\ 36''$

The time at the place of observation, in this case, appears to be less than the time at the first meridian, but it is really greater. In fact, a day more is reckoned on board the vessel, and 24 hours must be added to the time deduced from the calculation, which is the 16th of June at $1^{h}\ 39'\ 38''\ 24'''$, while at the first meridian it was only the 15th of June, and, at the instant of the observation, the hour was $15^{h}\ 41'$.

118. This method of obtaining the time at the place of observation should be employed only when the time of the observations cannot be estimated by a good watch. Whenever a marine chronometer or a good seconds watch is used, whether the observations be simultaneous, or the altitudes corresponding to the distance be calculated by proportion, an account must always be taken of the time at which each observation of the distance was made. Some time before observing the distance, or a little after the observations have been made, the sun's altitudes may be observed, which will give the time at the place where these altitudes were taken. The apparent distance, with the altitudes observed at the same place must be corrected, as in the preceding example; but then the difference between the time at the first meridian, concluded from the true distance, and the time at the place where the horary angle was observed, is to be taken: by this means, the longitude of the place will be obtained. This second method possesses a great advantage, when a

marine chronometer is used, which will also give the time at the place where the horary angle is observed; for it procures two results which can be directly compared with each other without any previous reduction being made. In the same case where the time of the observations can only be reckoned on a common seconds watch, the observation of a horary angle, taken before and after that of the distances, will have the advantage of greatly shortening the calculation. In fact, if a single series of observations of the distance be not thought sufficient, the same horary angle will suffice for calculating the longitude from all the series that have been observed.

119. It has already been remarked, that the time at the place of observation should not be calculated with the altitudes of the stars, but obtained from an altitude of the sun, taken either in the evening which precedes, or the morning which follows, the observation of the distance between the moon and a star; it has also been recommended to calculate the true altitudes of the two bodies with the hour at the place where the horary angle was observed, referred to that where the distance was observed by means of the way made in longitude in the interval between the two observations. If the time used in the calculations of the altitudes be compared with the time at the first meridian, concluded from the calculation of the true distance, the longitude of the place where the distances were observed will be obtained; but it would be better, as before, to take the difference of the time at the first meridian and that of the place where the horary angle was observed, in order to obtain a longitude that may be directly compared with that obtained by a marine chronometer.

120. The circumstances in which the distances of the moon from the stars can be taken, are much more frequent than those in which her distance from the sun can be mea-

sured. This kind of observation must not therefore be neglected, as it is often the only one from which the position of the vessel can be concluded. With a seconds watch, the observation of the distances between the moon and the stars is as easy as that between the sun and moon. It cannot be too much recommended to navigators, not to suffer themselves to be terrified by the length of the calculations, which, in this case, are indeed increased by that of the altitudes; what they may find difficult and tedious at the beginning will soon disappear: for, by exercising themselves during a short time will render the calculations familiar. Besides, it is useless to aim at an imaginary precision, of which the observation is not susceptible, and it will be sufficient to calculate the altitudes to a minute, and to take the logarithms only to five places of decimals. The calculation of the true distance of a star from the moon is the same as that of the distance between the sun and moon; and if attention be paid to all the abbreviations which have been indicated, the calculation of two or three series of observations may be made in a very short time. The following example may be used as an exercise. The rules that ought to be followed will be found in arts. 79 and 80, and in this chapter. We shall, therefore, give only a simple enunciation of the question, and the result of the calculation: but we have united in the same table, as has likewise been done with respect to the former example, all the data with the quantities necessary for the calculation; in which, they are arranged in the order most proper for facilitating the operations.

EXAMPLE II.

On the 19th of June, 1793, being in South latitude 9° 45′ 50″, and East longitude 148° 43′. When the time by the watch was 3h 41′ 5″·5 (*See the Examples in*

art. 81.), it was found from altitudes of the sun, that it was 1h 21′ 34″·3 behind true time. At 6h 8′ 10″·8 by the same watch, it was found from a series of six observed distances between the moon and *Antares*, that the distance of this star from the farthest limb of the moon was 39° 12′ 13″. It is required to find the longitude of the place where the horary angle was observed.

The calculated altitudes are the same as those in the example above referred to, where the operations necessary for finding them are explained.

Time at the place of obser. of the horary angle	31h 29′ 45″
Time at the first meridian - - - -	21 32 21
Difference - - - - - - -	9h 57′ 24″
LONGITUDE, East - - - - -	149° 21′ 0″

121. Whenever two or three series of distances can be observed, the longitude may be obtained to within about 15′ or 20′ of the truth. This error can never have a greater influence than from 5 to 6⅔ leagues upon the position of the vessel.

122. The true distance which is found by the preceding method, is obtained on the hypothesis that the earth is spherical. There are found, in almost all treatises on the calculations of nautical astronomy, the means of correcting it in order to find that which would have resulted from the calculation, if the earth had been considered as a spheroid flattened at its poles. It has been thought proper to omit these corrections in this place, because they can never be of sufficient consequence to merit attention; in the most favourable circumstances, they can never influence the calculated longitude more than 3′ or 4′ of a degree. But when the altitude must be calculated, the illipticity of the earth may be taken into the account without increasing the calculation; it would simply be necessary, instead of calculating

these altitudes with the latitude of the place, to employ that latitude diminished by a quantity which is found in collections of astronomical tables, and which is called the angle at the vertical. All mention of these corrections has been hitherto avoided,* in order that the calculation of longitude might not be rendered unnecessarily complicated; on the contrary, we have been desirous of finding methods of increasing its simplification.

123. The distances may be observed at land, and, in this case, they will give the longitude of the place for which the marine chronometer has been regulated; but as the probable error from each observation is 15′ or 20′, a great number of results should be obtained for determining the longitude of the same point, in order to diminish as much as possible the errors with which they may be affected. The probability of the accuracy of longitudes thus determined may still be increased, by deducing them in the following manner. In the first place, it should be recollected, that it has been said the same observer always measures the angles either a little too great or a little too small, either from the nature of his sight, or from the manner in which he is accustomed to make the limbs of the objects coincide in the field of the telescope. It follows from this, that the distances observed by the same person are all either *too* great or too little. The errors by which they may be affected from this cause are subject to variation, but those which act in one sense, on the time at the first meridian, concluded from observations made when the distances in the

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* There will be found in the notes subjoined to this treatise, and at the end of the explanation of the construction of Tables XII and XIII, the use that may be made of these tables for correcting the observed altitudes, and obtaining the proper quantities for computing the true distance, on the hypothesis that the earth is an oblate spheroid.

tables increase, will act in a contrary or opposite sense when the distances in the tables diminish. The distances increase when the sun or the star is on the west of the moon, and then the distances are called *west distances*; they diminish when the sun or the star is on the east of the moon, and, in that case, they are named *east distances*. It is therefore necessary to take an arithmetical mean between the mean longitude concluded solely from west distances, and that from east distances only, in order to obtain a final longitude, that may, in a great measure, be free from errors arising from the sight of the observer. It is probable that the errors in longitudes obtained by thus combining the results, will not amount to more than 10′ of a degree.

124. The distinction which is here made between the longitudes obtained from west distances, and those found solely from east distances, can only be of much utility when the results are derived from distances between the sun and moon: Many causes, the explanation of which would be too long in this place, render the distances between the moon and the stars subject to irregularities, the different influences of which it is impossible to ascertain, from the circumstances that accompany the observations; hence the longitude of the port arrived at should always be determined from the mean longitude of all the observations, which can be taken without making the distinction between the longitudes obtained from east and those from west distances. The errors of longitudes obtained from distances between the moon and the stars, ought never to exceed 15′ of a degree; they will therefore be susceptible of an accuracy a little less than that derived from distances between the sun and the moon: this is the reason why they should be employed in ascertaining a geographical position, only when a sufficient number of the latter observations cannot be obtained.

125. Longitudes observed at sea are generally concluded

from distances taken in different places, which, at first sight, do not appear capable of giving the position of the vessel with any great accuracy; it will, nevertheless, be easy to give them a precision, whenever a good marine chronometer is used, equal, perhaps, to that of the longitudes observed during a period of anchorage. In fact, these chronometers afford the means of measuring, with accuracy, the differences of longitude of all the places where the distances have been observed; it will therefore be possible to refer the results of longitudes observed at different places to the same place, the longitude of which will have a much greater precision than if it had been determined from the small number of observations which it was possible to make at that place. Whenever the following rules can be complied with, the longitude will only be affected with the error arising from that of the distances; and the influence of the errors of different longitudes, taken even a long time after the chronometer has been regulated, may be considered as nothing.

126. Refer the longitudes from distances which have been taken on consecutive days, or those but little distant from each other, to the place of which the longitude has been determined by the marine chronometer, in the morning or evening of the day which is equally distant in time from the extreme observations of the distance.

If the longitudes obtained from distances between the sun and moon are required, refer all the longitudes from east distances to the same point. In the same manner, those obtained from west distances are to be referred to another point; then the longitude of a third point is to be calculated by referring the longitudes of the two intermediary days, one of which was the result from east, and the other from west distances, to the place where the longitude has been found by the chronometer, in the morning or evening of the day equally distant in time from the two intermedi-

ary days above mentioned. The longitude of this third point will have all the accuracy of which the method of distances observed at sea is susceptible: it will even be nearly as accurate as the longitude obtained from observations made at the place itself.

127. When the longitudes obtained from distances between the moon and the stars are required, the mean longitudes which have been deduced from two or more series of observations, may be referred to a single point in the same manner, but without any distinction into those from east and west distances: the only attention which is necessary is, that the interval between the intermediary days, answering to each series of observations, may not exceed 20 or 30 days. By this means, so great a number of observations may be made to concur in determining the longitude of a single place, that it will be obtained with a precision, perhaps, equal to that of the longitude derived from distances between the sun and the moon.

CHAPTER VII.

On finding the Declination of the Magnetic Needle, by Observations of the Sun's Azimuth or Amplitude, and by the Astronomical Bearing of a terrestrial Object.

128. The declination of the magnetic needle is the angle which the direction of this needle makes with the north and south line. If the bearing of a terrestrial object situated exactly north and south, be taken, the observation will give directly the declination of the needle; but as all the points of the compass make, with the true points of the horizon, angles equal to its declination, it will be sufficient to take any object, the true bearing of which is known: then the difference of this bearing, and that which has been observed, is the declination required. The question is, therefore, reduced to that of finding, by any means, the true bearing of an object so situated that its bearing can be taken with the compass. The sun is the only object which can be conveniently observed with the compass at sea. The bearing of the sun is an arc of the horizon comprised between the vertical circle and the meridian of the place, and ought therefore to be equal to the angle formed by these two circles, or to the azimuth of the sun. This azimuth must therefore be found from calculation for the instant that his bearing is taken. Nautical astronomy also teaches the means of observing and calculating the true bearings of terrestrial objects: hence, near the

shore, observations of these objects may be employed for finding the declination of the magnetic needle. These last bearings are called *Astronomical bearings*; and as they are those which are susceptible of the greatest degree of precision, and also contribute much to the perfection of hydrographical or marine charts, it is proposed to treat of them here at some length.

Calculation of the Sun's Azimuth and Amplitude.

129. It has already been remarked, that the altitude of the sun varies at every instant of his course, and that the time at any place may be found by an observation of this altitude: the sun's azimuth, corresponding to the same instant of observation, may also be obtained by calculation. Hence, when it is wished to ascertain the declination of the magnetic needle, it is only necessary to observe the sun's azimuth with a compass at the same instant that his altitude is taken. The difference of the observed and calculated azimuths will be the required declination.

130. The circumstances under which the observation of the sun's altitude gives his azimuth with the greatest accuracy, are nearly the same as those in which that altitude ought to be observed for ascertaining the time at the place where the observations are made. Now, as the calculated azimuth is almost always susceptible of much greater accuracy than the azimuth observed with the compass, it will not be necessary in the present case, to pay any regard to the rules that have been given relative to the circumstances which should accompany an observation of the horary angle. It will always be most advantageous to make the observation when the sun is very near the horizon; then his azimuth may be observed with a compass, much more easily than when he has attained a certain altitude. The errors with which the calculated azimuth

may, in this case, be affected from the uncertainty of refraction and the latitude of the place, will be very small in comparison with those of which the observed azimuth is itself susceptible. Whenever, in looking at the horizon with a reflecting instrument, the direct image of the sun cannot be seen in the field of the telescope, we may commence the observation: the altitude will then be a little more than four degrees. The bearings of the sun become susceptible of great errors when he has attained 15° of altitude; the azimuth should not, therefore, be observed when his altitude exceeds 15°. We might, in strictness, practise this kind of observation, as often as the sun can be seen through the sights placed on the lid of the compass; but when it is desired to obtain all the accuracy of which it is susceptible, the observation must terminate when the altitude is equal to 15°.

131. While two observers are occupied in taking the bearing of the sun with a compass, a third observer should take the altitude of the sun with a sextant or a reflecting circle; bringing the sun's image to the horizon, and, following its movements with the repelling screw of the instrument, always preserving its lower limb in contact with the horizon. At the moment when the two observers who take the bearing are certain of having made a good observation, they inform him who takes the altitude, and he reckons the arc marked by the index on the limb of his instrument: which will be the altitude corresponding to the observed azimuth. Another observation may be made, and the mean altitude concluded, answers to the arithmetical mean between the two observed azimuths. If the altitude be taken with a reflecting circle, the arc passed over by the index should be reckoned only at the end of the second observation; and the mean altitude corresponding to the mean azimuth, may be concluded in the usual manner. It

would be advantageous to observe in this manner several series, each consisting of two observations; the arithmetical mean of the declinations deduced from each of these series, will be susceptible of considerable accuracy. It is not necessary to reckon the time at which each of these observations was made on a seconds watch; the estimated time will be sufficient, which may differ 15′ or 20′ from the true time at the place of observation without inconvenience.

132. The following is the method of calculating the azimuth. Calculate the time at the first meridian corresponding to the instant of the observation, by means of the estimated time at the place, and the longitude by account. Search in the Nautical Almanac the declination of the sun for the time of observation, from which his distance from the elevated pole may be concluded. This polar distance, the true altitude which is to be deduced from the observed altitude by the rules in Chapter II, and the latitude of the vessel, are the three data necessary for the calculation, which is to be performed as follows.

Write below each other in the following order, the distance of the sun from the elevated pole, his true altitude, and the latitude. Add these three quantities together, and take half their sum. Then below this half sum write the difference between it and the polar distance; that is, subtract the less of these quantities from the greater. Take, in the tables, first, the arithmetical complements of the logarithm cosines of the true altitude of the sun and the latitude; then write below these complements the two logarithm cosines of the half sum, and the difference between this half sum and the polar distance. Add these four logarithms together, and half their sum will be the logarithm cosine of half the azimuthal angle: double of the corresponding arc will be the sun's azimuth, which is always reckoned to commence towards the elevated pole: hence, if

the elevated pole is in the northern part of the meridian, the azimuth will be reckoned from the north; but if the elevated pole is towards the south, the azimuth will be reckoned from the south. The azimuth observed with the compass must consequently commence at the same part as that obtained by calculation, that the declination of the magnetic needle may be deduced by comparing them together.

The calculation of the azimuth may be made without regarding the seconds of a degree; and the logarithms need only be taken to five places of decimals.

133. It has already been observed, that the declination of the needle is equal to the difference between the azimuth observed with the compass and that derived from calculation; but in order to know on which side of the meridian it should take place, it will be necessary to attend to the following remarks: suppose, for a moment, that we were turned towards the sun, and looking in the direction of his bearing; then it would be very easy to know whether the azimuth resulting from the calculation, answered, on the card of the compass, to the left or *larboard* side of the azimuth observed with the compass; or whether it corresponded to the right or *starboard* side. But the direction of the magnetic needle ought to be situated, with respect to the north and south line, exactly in the same manner as the calculated azimuth is situated with respect to that which has been observed with the compass; hence, whenever the calculated azimuth answers on the card of the compass to the larboard of that observed with the needle, it follows, that the direction of the needle ought to be to the larboard side of the north pole: in this case, the needle declines towards the west, and its declination takes the name of north-west. If the calculated azimuth place the sun on the starboard side of the observed azimuth, the needle declines towards the east, and the de-

clination take the denomination of north-east. Mariners commonly call the declination of the needle the *Variation of the Compass*, and say that the variation is north-east or north-west.

134. When the needle declines two points of the compass towards the north-west, or to the larboard side of the north, the true direction of the north point of the compass is the north-north-west; and when it declines two points towards the north-east, or starboard side, the true direction of the same point of the compass is north-north-east. The corrected point is therefore always situated, with respect to the observed point, in the same manner as the north of the compass is with regard to the north of the world. This consideration induces us to believe, that there would be an advantage in applying both these denominations to the declination of the magnetic needle; we should say, for example, declination north-west or larboard, and declination north-east or starboard. This double appellation would afford a very simple general rule for correcting the course of a vessel and the bearings observed with the compass. It would be sufficient to employ the declination of the needle in such a manner that the corrected bearing may be on the larboard or the starboard of the observed bearing, according to the denomination which that declination ought to have. The denominations of north-east and north-west are more naturally derived from principles, and are essential to those who occupy themselves with the theory of magnetism; the other denominations would be a great convenience in practice, and might prevent many mistakes that take place, only because men, even the most experienced, are subject to be deceived relative to the true sense in which the bearings should be corrected. Mariners are, doubtless, guided by an analogy of this kind, when they say that the lee-way is on the larboard or starboard, and that

the variation is on the same or the opposite side. It is not attempted to introduce a new term, but only proposed to render a denomination general, which has been used in a particular case.

EXAMPLE.

On the 2nd of March 1792, at about six in the morning, being in South latitude 34° 48′, and East longitude 35° 49′ the altitude of the sun's lower limb, was observed to be 6° 15′. At the same instant the sun's azimuth, observed with the compass, was 57° 17′; that is, the centre of the sun was taken at 57° 17′ from the south towards the east; the elevation of the eye was $20\frac{1}{4}$ feet above the surface of the sea Required the sun's true azimuth, and the declination of the needle.

The time at the first meridian corresponding to the instant of the observation is the 1st of March, at 15^h 37′; the declination of the sun for that time was 6° 57′ South. But the latitude is of the same denomination as this declination, consequently, the distance of the elevated pole is 83° 3′. The true altitude of the sun's centre is 6° 19′. The given quantities may be disposed, and the calculation performed in the following manner.

Distance of the elevated pole	83°	3′		
True altitude of the ⊙. -	6	19	comp. cos.	0·00264
Latitude - - -	34	48	comp. cos.	0·08558
Sum -	124°	10′		
Half sum	62	5	- - cos.	9·67042
Polar distance — ½ Sum -	20	58	- - cos.	9·97025
	Sum	-	-	19·72889
	Half sum		cos.	9·86444
	Half azimuth		42°	57′

Double. Azimuth from the South to the East.	85° 54′
The sun's bearing was from the South -	57 17 E.
DECLINATION of the magnetic needle -	28° 37′N.W. or larboard.

In this example, the south pole is that which is elevated above the horizon, consequently, the calculated azimuth of the sun is reckoned from that pole. The azimuth observed with the compass must also be reckoned from the same pole, and it is S. 57° 17′ East. The difference of this observed azimuth, and that which results from the calculation, is the required declination of the needle, and is found to be 28° 37′. Now, in order to know in what direction this declination ought to take place, it may be remarked, that the calculated azimuth being greater than the azimuth observed with the compass, it ought to answer on the card of the compass to the left or larboard of the observed azimuth; it follows then, that the declination of the needle is north-west; and if we adopt the double denomination which has been proposed, it will be north-west or larboard

135. The instant at which the sun's bearing can be the most easily taken with the compass, is that of his rising or setting, because he is then found very nearly in the plane of the compass card. Mariners make more use of this observation, than of the preceding one, because the calculation is shorter, and it is not necessary to observe the sun's altitude, which is nothing when his centre is in the horizon but the result is not susceptible, as will be seen, of so much precision as it is possible to attain by the other method. There are inserted in almost all collections of tables on nautical astronomy, tables of a double entry, by the assistance of which it is easy to find, with the latitude of the place and the declination of the sun, his amplitude at the moment of his

rising or setting. This arc is only a part of the horizon comprised between the sun and the true east or west point; it is the complement of the sun's azimuth, or, in certain cases, it is equal to the quantity which this azimuth exceeds 90°. The difference of the amplitude found in the tables, and that observed with the compass, is equal to the declination of the needle. It may be known by means similar to those which have been given for the azimuth, whether the needle declines towards the north-east or north-west.

The table of amplitudes, in order to be useful, ought to have a certain extent. The limits to which we have been obliged to confine the collection of tables at the end of this treatise, has obliged us to suppress this; but its place may be supplied by a very short calculation, which will give the sun's amplitude by the addition of two logarithms of five figures each.

136. Before making the calculation, find the time at the first meridian corresponding to the moment of the rising or setting of the sun; and take, from the Nautical Almanac, the declination of the sun at that instant. Then add the logarithm sine of the declination to the arithmetical complement of the logarithm cosine of the latitude, and the sum will be the logarithm sine of the sun's amplitude. When the sun is found on the north of the equator, his rising and setting will be north of the east and west line; and when he is on the south of the equator, he rises and sets on the south side of the same line; the amplitude is therefore always of the same denomination as the declination.

137. The amplitude found in the tables, and that obtained by the preceding calculation, supposes the bearing of the sun to be taken with the compass, at the instant when his centre was really in the horizon; but, on account of refraction, the centre of the sun ought then to appear to have an elevation of 33′, it will therefore be necessary to

observe the bearing only when the sun's lower limb has an altitude nearly equal to his semi-diameter. It is the difficulty of seizing this instant that renders the declination of the needle concluded from observations of the amplitude, less susceptible of precision than those which result from observations of the azimuth. Nevertheless, when the sun is taken a short time before his lower limb is detached from the horizon, and again when the altitude of this limb does not appear greater than his whole diameter, then the error of the calculated amplitude will never be much more than half a degree, provided the latitude do not surpass 60°. But, on the other hand, the observed amplitude may be affected with an error of half a degree: also, when circumstances are not very favourable, that is, when the sea is but slightly agitated, the declination of the magnetic needle may be obtained within nearly a degree; this accuracy is sufficient for the purposes of navigation; but if it be wished to obtain it with greater precision, observations of the sun's azimuth only must be employed.

EXAMPLE.

One the 11th of June 1792, at about 6^h 50′ in the morning, being in South latitude 27° 10′, and East longitude 164° 22′; the easterly amplitude of the sun was observed with the compass, and found to be 37° 27′ towards the North. Required the declination of the magnetic needle.

The time at the first meridian, at the moment of the sun's rising at the place of observation was the 10th of June at 7^h 53′, consequently, his declination was 23° 7′ North.

Declination of the ⊙ North	23°	7′	sin.	9·59396
Latitude	27	10	comp. cos.	0·05077
			Am. sin.	9·64473
Amplitude of the ⊙.			E.	26° 11′ N.

Amplitude of the ☉. - E.	-	26° 11′ N.
The sun was taken to the E.	-	37 27 N.
DECLINATION of the magnetic needle.		11° 16′ N.E. or starboard.

In this example the calculated bearing answers on the card of the compass, to the right or starboard of the bearing taken with the compass; the declination of the needle is therefore North-East or starboard.

On Astronomical Bearings.

138. Having given the method of calculating the azimuth or bearing of the sun from an observation of his altitude; if, at the same time that his altitude is taken, the distance between the sun and a terrestrial object be measured, and the altitude of that object be observed, nautical astronomy furnishes the means of calculating, from these data, the difference between the bearings of the sun and that object at the moment of observation. The bearing of the sun being known, and the difference between this bearing and that of the object, the bearing of this last is easily determined. It is these bearings that are called astronomical bearings, because they are immediately derived from observations of the heavenly bodies. They are the most proper, as will be shewn, for ascertaining the declination of the magnetic needle; they ought also to be employed in preference to bearings taken with the compass, in the construction of hydrographical or marine charts.

139. The observation of astronomical bearings requires the concurrence of two observers; while one takes the altitude of the sun, the second measures the distance of the object from his nearest limb. Two observations of this distance and altitude may be taken, and the mean of each

deduced. The altitude of the object should always be very small, and may not vary by a sensible quantity in a short interval of time, it may therefore be measured a little before or after the observations of the altitude and distance of the sun. As it is not necessary to take the bearings of terrestrial objects to a small number of seconds, the rules that have been recommended to be observed in taking the distance of the moon from the sun or the stars need not be attended to here; hence the exact simultaneous observations of the sun's altitude, and his distance from the object will not always be absolutely necessary.

The hour, minute and second at which the observation was made need not be taken, and the quantities taken from the Nautical Almanac may be calculated with the time at the first meridian, deduced from the estimated time at the place of observation, which may be 15 or 20 minutes from the exact time without inconvenience.

When it is intended to deduce the declination of the magnetic needle from the astronomical bearing of a terrestrial object, two other observers must take the bearing of the same object with the compass, at the instant its distance from the sun is observed. This method of observing the declination of the needle requires the assistance of four observers, that is, one person more than when it is obtained from the azimuth of the sun. The method of amplitudes requires only two observers, and this is one of the reasons which renders it more convenient in practice.

140. The calculation of astronomical bearings, from what has been said above, consists of two parts; 1st. the calculation of the sun's azimuth; 2nd, the calculation of the difference of the azimuths of the sun and the object. Hence the accuracy of the result depends upon that with which the sun's azimuth is obtained from his altitude; and also the precision with which the calculated difference of the

azimuths is determined. It has been shown that the motion in altitude is very slow near the meridian; consequently, altitudes taken near the meridian are not proper for ascertaining the corresponding azimuth.* In general, the azimuth of the sun should never be calculated with altitudes taken within an hour and a half of noon. The altitudes taken at any other time of the day, give the azimuth within about 2′ of the truth. There are circumstances in which the astronomical bearings may be obtained from a distance observed between half past ten in the morning and half past one in the afternoon, but then it is necessary to calculate the sun's azimuth with the horary angle instead of his altitude. The method of performing this calculation will be given in the subsequent pages.

141. All circumstances are not equally favourable for observing the difference between the azimuth of the sun and that of a terrestrial object; observations may even be made, the results from which would be very defective; this renders it essential to consult the following precepts, before the observations are made, and if care be taken to conform to them, the azimuth will be obtained, in all cases, within 2 or 3′ of the truth.

1st. Never observe the astronomical bearing when the altitude of the sun exceeds 60°.

2nd. Choose an object when it is nearly 90° distant from the point where the vertical circle of the sun cuts the horizon.

3rd. When an object cannot be observed about 90° from the vertical circle of the sun; choose another, so situated with respect to the sun, that the angle of inclination of the instrument with which the distance is measured, may not be more than 45°.

An error of 10° or 12° in the estimate, either of the difference between the azimuths of the sun and object, or in the

inclination of the instrument with which the distance is measured, will not have a great influence upon the result.

142. The following are the rules which ought to be observed in procuring the quantities necessary for the calculation. From the estimated time and longitude, the time at the first meridian corresponding to the moment of observation must be deduced; then take from the Nautical Almanac the sun's declination at that instant, by which the distance of the elevated pole is to be found. Correct the observed altitude of the sun for the depression of the horizon and semi-diameter, and his apparent altitude will be obtained, which must be diminished by refraction, to have the true altitude, with which the calculation of the azimuth is to be performed, according to the rules in art. 139. Add the semi-diameter of the sun to the observed distance, when his nearest limb was brought into contact with the object; but subtract it when his farthest limb was used. In these two cases, the apparent distance between the centre of the sun and the object will be obtained; the depression of the horizon must also be subtracted from the altitude of the object, and the remainder will be its apparent altitude, which, with the apparent altitude and distance of the sun, are to be used in finding the azimuths, according to the rules given in the following article.

143. Write, in the following order, the apparent distance, and the apparent altitudes of the sun and object; add these three quantities together, and take half their sum; also take the difference of that half sum and the apparent distance. Then take the arithmetical complement of the logarithm cosines of the apparent altitudes of the sun and object. Write below these two complements, the logarithm cosines of the half sum, and the difference of the half sum, and the apparent distance. Half the sum of these four logarithms

will be the logarithm cosine of the half difference of the azimuths of the sun and object. Double of the corresponding angle will be the difference of the azimuths required.

Suppose, for a moment, that we face the elevated pole, and remark whether the vertical circle of the sun is to the right or left of that pole; and also whether the object of which the distance had been taken is to the right or the left of this vertical circle. When the vertical circle of the sun is on the left of the elevated pole, and the object on the left of that circle, add the difference of the azimuths to the azimuth of the sun. The same addition must also be made, under the same circumstances on the right of the elevated pole; but when the sun is on the right of the elevated pole, and the object on the left of his vertical circle, and reciprocally, the difference between the sun's azimuth, and that which results from the calculation, must be taken. The azimuth of the object calculated, according to these rules, will always be reckoned to commence at the elevated pole, and in the same direction as the sun's azimuth: this rule is general when the sum of the results of the two calculations is taken; but in the case in which they have been subtracted from each other, and the difference of the azimuths is greater than the azimuth of the sun, then the azimuth of the object ought to be reckoned in a contrary direction to that of the sun; that is, the one will be towards the east, and the other towards the west.

EXAMPLE.

On the 10th of July 1792, at 7 in the morning, being in south latitude 7° 31′, and east longitude 153° 10′, the altitude of the sun's lower limb was observed to be 10° 30′; at the same time, the distance between the summit of a distant mountain and his nearest limb was taken, and found to be equal to 95° 16′. This mountain was situated on the left

of the vertical circle of the sun, and the observed altitude of its most elevated part was, at the instant of the observation, 3° 20′; the elevation of the observer's eye was $20\frac{1}{4}$ feet. Required the bearing of the mountain.

Latitude, South - - - - -	7° 31′
East Longitude - - - - - -	153 10
In time - - - -	10ʰ 37′
Estimated time at the place of observation -	19 0
Time at the first meridian - - -	8ʰ 23′
Declination of the ⊙. - - - -	22° 14′N.
Distance of the elevated pole - -	112 14
Observed altitude of the ⊙. - - -	10° 30′
Elevation of the eye $20\frac{1}{4}$ feet. Depression -	— 4
	10° 26′
Semi-diameter of the ⊙. - - - -	+ 16
Apparent altitude of the ⊙. - -	10° 42′
Refraction - - - - -	— 5
True altitude of the ⊙. - - -	10° 37′
Distance of the nearest limb of the ⊙. -	95° 16′
Semi-diameter of the ⊙. - - - -	+ 16
Distance of the centre of the ⊙. - -	95° 32′
Altitude of the mountain - - -	3° 20′
Elevation of the eye $20\frac{1}{4}$ feet. Depression -	— 4
Apparent altitude of the mountain - -	3° 16′

Calculation of the Azimuth of the ⊙.

Polar distance of the ⊙.	112° 14′		
True altitude of the ⊙.	10 37	comp. cos.	0·00750
Latitude - - -	7 31	comp. cos.	0·00375
Sum - - -	130° 22′		
Half sum - -	65 11	- cos.	9·62296
Polar distance — ½ Sum	47 3	- cos.	9·83338
	Sum - -		19·46759
	Half Sum -	cos.	9·73379
	Half azimuthal angle		57° 12′
Double. The sun is from the South		-	114° 24′E.

Calculation of the difference of the azimuths.

Appar. distance of the ⊙.	95° 32′		
Appar. altitude of the ⊙.	10 42	comp. cos.	0·00762
Appar. alt. of the mount.	3 16	comp. cos.	0·00071
Sum -	109° 30′		
Half sum	54 45	- cos.	9·76129
Appar. dist.—Half sum	40 47	- cos.	9·87920
	Sum - -		19·64882
	Half sum	cos.	9·82441
	Half diff. of the azimuths		48° 8′
The mount. *on the left* of the vertical circle of ⊙. difference of azimuths. -			96° 16
The ⊙. *to the left* of the elevated pole, remains to the south. - - -			114 24 E.
Add. The Mountain was to the S.			210° 40′E.
Subtract 180° - - or to the N.			30 40W

The latitude in this example is south, consequently the

south pole is the elevated pole, and all the bearings that are immediately derived from calculation, ought to be reckoned from that pole. The azimuth of the sun is 114° 24′, and because the observation was made in the morning, his bearing is south 114° 24′ east; the vertical circle of the sun was therefore on the left of the elevated pole. But at the time of the observation, the mountain was also on the left of the vertical circle; hence the azimuth of the sun must be added to the difference of the azimuths; this sum will be the bearing of the mountain, reckoned from the south pole towards the east, the same way as the azimuth of the sun is counted. In the present case, the sum of the two quantities is equal to 210° 24′, and it is greater than 180°, which shews that the mountain is beyond the north pole, and to the left of that pole; consequently 180° must be subtracted from it, and the remainder will be the bearing of the mountain, or north 30° 24′ west, as above.

144. It has been said that the azimuth of the sun might be obtained to nearly 2′; the difference between his azimuth and that of the terrestrial object may be equally ascertained to 2′ or 3′. Consequently, if we conform to the rules that have been given relative to the circumstances under which the observation should be made, we may be certain that the astronomical bearings resulting from the calculation will not be affected with an error of more than 4 or 5 minutes.

145. When the sun passes the meridian at a less altitude than 60°, it is possible, as already remarked, to obtain the astronomical bearing of a terrestrial object, by an observation made within an hour and a half of noon. These bearings may even be observed very near the passage of the sun over the meridian. In this case, the time corresponding to the observed distance between the sun and the object must be reckoned on a seconds watch, the gain or loss of which, with respect to true time, had been ascertained near the time at

which this distance was taken. The gain or loss of the watch will serve to find the time which ought to be reckoned at the place of observation of the horary angle, at the moment in which the observation of the astronomical bearing was made. By means of the way made in longitude, this time must be referred to the place where the bearing is observed, and the true time corresponding to the distance between the sun and the object will be ascertained. If this distance has been taken before the passage of the sun over the meridian, by taking its complement to 24 or 12 hours, we shall have the horary angle of the sun; but when the observation is made after noon, the horary angle will be equal to the time at the place of observation. By means of the longitude, the time at the first meridian may be calculated; this time will then serve to find the sun's declination, by which the distance of the elevated pole may be obtained. The polar distance of the sun, the complement of the latitude, and the horary angle of the sun, are the three data, with which the azimuth must be calculated; the following are the rules to be observed.

146. Write down the polar distance of the sun, and below it the complement of the latitude; take the sum and difference of these two quantities. Write, in succession, the half sum and the half difference, and below them write the horary angle, and take its half. Add together the arithmetical complement of the logarithm sine of the half sum, the logarithm sine of the half difference, and the logarithm cotangent of half the horary angle; the sum of these three will be the logarithm tangent of an arc which is called the first angle. Write down on the right hand of the former logarithms, the arithmetical complement of the logarithm cosine of the half sum, the logarithm cosine of the half difference, and the logarithm cotangent of half the horary

angle. Add these three logarithms together, and the sum will be the logarithm tangent of a second angle, the arc corresponding to which must be taken from the tables.

It is to be remarked that these two calculations have a common logarithm, and that there is only to look in the tables for five logarithms. The calculations will be much abridged if the seconds of all the given quantities are suppressed, and the logarithms taken only to five places of decimals. These given quantities may be placed as in the following example; then immediately after taking the arithmetical complement of the logarithm sine of the half sum, that of its cosine, which it by its side, may be taken; in the same manner the logarithm sine and cosine of the half difference may be taken, at one opening of the tables.

When the sun passes the meridian towards the depressed pole, add the 1st and 2nd angles, that have been found by the calculation, together, their sum will be the sun's azimuth, which will be reckoned from the elevated pole; that is, in this case, from the side opposite the passage of the sun over the meridian: it will, therefore, be greater than 90°, and often near 180°.

When the sun passes the meridian towards the elevated pole, take the difference of the two angles found by the calculation; this difference will be the sun's azimuth, which will be reckoned from the elevated pole, that is, from the side on which the sun passes the meridian, and in this case it will always be less than 90°.

The difference of the azimuths of the sun and the observed object, is to be calculated by the rules in art. 142, and the azimuth of the object, or its bearing, may be obtained in the same manner as when the sun's azimuth was calculated from his altitude.

These rules are illustrated by the following example.

EXAMPLE.

On the 17th of June 1792, being in south latitude 22° 53′, and east longitude 164° 43′, when the time by the watch was 2^h 25′ 31″, the distance of the nearest limb of the sun from the most elevated summit of the isle of Pines, situated at the south-east extremity of New Caledonia, was found to be 85° 51′. This island was on the right of the vertical circle of the sun. The altitude of his lower limb at the same instant was 43° 41′; that of the object 5° 10′; and the eye of the observer was elevated 20¼ feet above the surface of the sea.

It was known, from observations of the sun's altitude made in the morning, that the watch was 2^h 2′ 27″ before true time; the place where the bearing was observed was 2′ of a degree, or 8″ of time, to the west of that where the horary angle had been ascertained.

Time by the watch - - - -	2^h 25′ 31″
Before true time. *Subtract.* - - -	2 2 27
Time at the place of the horary angle -	0^h 23′ 4″
The place of the bearing to the W. - -	— 8
True time of the bearing, or horary angle -	0^h 22′ 56″
Horary angle in degrees - - -	5° 44′
Latitude S. - - - - - -	22° 53′
Complement of latitude - - -	67 7
Longitude East - - - - -	164° 43′
Longitude in time - - - -	10^h 59′
Time of observing the bearing - -	0 23
Time at the first meridian - -	13^h 24′
Declination of the ⊙. N. - - - -	23° 25′
Distance of the ⊙. from the elevated pole -	113 25

Observed altitude of the ⊙. - - -	43° 11′
Elevation of the eye 20¼ feet. Depression. -	— 4
	43° 7′
Semi-diameter of the ⊙. - - - -	+ 16
Apparent altitude of the ⊙. - - -	43° 23′
Distance of the nearest limb of the ⊙. -	85° 51′
Semi-diameter of the ⊙. - - -	+ 16
Distance of the centre of the ⊙. -	86° 7′
Observed altitude of the mountain. -	5° 10′
Elevation of the eye 20¼ feet. Depression. -	— 4
Apparent altitude of the mountain. -	5° 6′

Calculation of the Sun's Azimuth.

Dist of ⊙ from elev. pole	[illegible] 25′		
Comp. of the latitude	[illegible] 7		
Sum - -	180° 32′		
Difference - -	46 18		
Half sum -	90° 16′	comp. sin. 0·00000	comp. cos. 2·3[illegible]16
Half difference -	23 9	- - - sin. 9 59455	- - - cos. 9·9635[illegible]
Horary angle -	5 44		
Half horary angle -	2 52	cotang. 1 30038	cotang. 1·30038
		tang. 0·89493	tang. 3·59608
		1st angle 82° 44′	2nd angle 89° 59′
			1st angle 82 44
The sun passes the meridian towards the depressed pole.			Add. 172° 43′
The sun remains to the S. - - -			172° 43′W

Calculation of the difference of the Azimuths.

Appar. distance of the ⊙.	86° 7′			
Appar. altitude of the ⊙.	43 23	comp. cos.	0·13860
Appar. alt. of the mount.	5 6	comp. cos.	0·00172
Sum - - -	134 36′		
Half sum - -	67 18	cos.	9·58648
Appar. dist.—Half sum	18 49	cos.	9·97615
	Sum - - -		19·70295
	Half sum -	cos.	9·85147
	Half diff. of the azimuths		44° 44′
The Mount. ON THE RIGHT *of the vertical circle of* ⊙. difference of azimuths. -			89 28
The ⊙ ON THE RIGHT *of the elevated pole*, remains from the south. -			172 43 W
Add -	THE MOUNTAIN is from the S.		262 11′W
Subtract 180 - -	or from the N.		82 11 E.

The observation was made after noon, consequently the sun was on the right of the south pole, which, in the present case, was the elevated pole; but the mountain was also on the right of the vertical circle of the sun, the difference of the azimuths must therefore be added to the azimuth of the sun. The sum 262° 11′ is an arc reckoned from the south pole towards the west, or in the same direction as the sun's azimuth. This arc being greater than 180°, terminates beyond the north. Therefore 180° must be subtracted from the sum that has been found; then the true bearing of the mountain is north 82° 11′ east, as shewn above.

147. Astronomical bearings observed near noon are not, in general, susceptible of such accuracy as those which result from observations made when the sun is but a little elevated

above the horizon; but they are always preferable to bearings observed with the compass, provided the rules given in art. 141, relative to the circumstances under which the observations ought to be made, are attended to. When the elevation of the sun does not exceed 40°, the error with which they may be affected will never be more than 6′ or 8′; and if the sun's altitude approach to 60°, the error will not surpass 12′ or 14′. It may now be useful to remark that the errors will, almost always, be much less than the quantities here assigned them.

148. When astronomical bearings are to be employed in the construction of hydrographical or marine charts, an object must be chosen on the shore which is best defined, and most advantageously situated with respect to the vertical circle of the sun and the bearing observed. Now, when this observation is made, several observers should take the angular distances between the object fixed upon, and all the other objects that are to be placed on the chart, with reflecting instruments. It will be easy to conclude, from all these angles, the bearing of each particular object. The errors in the angular distances, measured with octants or common sextants, will never be more than 1′ or 2′. Bearings observed in this manner, will therefore have nearly the precision of the astronomical bearings from which they have been derived; and the charts constructed from these bearings will consequently possess very great accuracy.

149. Circumstances do not always permit astronomical bearings to be observed; then we are obliged to take the bearings with the compass, but in this case the following method should be adopted: it possesses the advantage of remedying a part of the imperfections of which bearings taken with the compass is susceptible. It may be supposed, from what has been said, that the declination of the magnetic needle has been determined as accurately as possible

by the method explained in this chapter. Choose a very distinct object, and sufficiently distant that its bearing may not be sensibly changed during the short time occupied by the observation; those objects that are seen very nearly, either before or behind the vessel, ought to be preferred. Observe, first, the bearing of the chosen object with the compass; then derange its sights, and take a second bearing. Three or four observations may be taken in the same way, and there will be obtained from the mean of all these, a final bearing, which will be much more exact than if a single observation only had been made. While this bearing is taken, other observers should measure, with reflecting instruments, as in the preceding case, the angular distances between the object fixed upon, and all the others which are to be inserted in the chart; these angles will give the bearing of each of the objects in particular. The angular distances may be considered as very exact; since the errors of all the bearings will be nearly the same, and consequently will have little influence on the relative positions which were derived from these bearings.

NOTES.

THE object of the preceding treatise was not to show the manner of making astronomical observations at sea; but to explain at some length the methods of calculating them. It was thought requisite to add to the rules that have been prescribed, some elucidations proper for facilitating their application. It is with this view that we have endeavoured to explain, by such simple reasonings as might be understood by all classes of readers, the different rules that are derived from the elementary principles of the sphere; but it was indispensable to refer those demonstrations which involve the more complicated theory of spherical triangles, to the end of the work; and this is the place for fulfilling the engagement which has been made. It shall be shown how the formulæ are to be found, according to which the different calculations of the various examples that have been given are performed; then the principles of the construction of the new tables, for referring an altitude taken in any place to another place a little distant from the former, and situated under the same meridian, shall be developed. It will be seen, and perhaps not without interest, that these tables may also be used for correcting the observed altitudes of the sun and moon, in order to obtain the reduced distance of these two bodies, upon the hypothesis that the earth is a spheroid flattened at the poles. We shall give, lastly, a demonstration of a very simple method, which has been mentioned in the 2nd chapter, for calculating the inclination of the visual ray, when it meets the shore

by which the horizon is bounded. This will explain the reasons which have caused it to be used.

Let Z H N O figs. 1, 2, be the meridian, Z the zenith, and H O the horizon. If P be the elevated pole and E Q the equator, the arc P O will be equal to the latitude, and Z P will be its complement to 90°. Suppose the sun to be at the point S of the parallel to the equator R V, the arc P S will be the distance of the sun from the elevated pole, and the arc S I will be his altitude; consequently S Z, which is his zenith distance, will be the complement of his altitude. The triangle Z P S is formed by the polar distance S P, and by the sides Z P and Z S, which are the complements of the latitude and altitude. It ought to be observed that the angle Z P S, formed by the circle of declination S P and the meridian, is the horary angle of the sun S; the angle P Z S formed by the vertical circle and the meridian, is the azimuth; lastly, the angle Z S P, formed by the vertical circle Z S and the circle of declination P S, is the angle of variation. Whether it be required to find the horary angle or azimuth of a heavenly body by an observation of its altitude, or to calculate the altitude from the horary angle, or the latitude with the angle of variation, it is necessary to resolve the triangle Z S P.

Call the altitude S I of a heavenly body H, its distance from the elevated pole D, the latitude P O call L, and let A denote the horary angle Z P S, A the azimuth P Z S, and V the angle of variation Z S P, which will give denominations to all the parts of the triangle Z P S; and these are employed in the following calculations.

Trigonometry teaches the method of finding a great number of different formulæ, any of which would be proper for calculating one of these six quantities when three of the others are given. Of these known methods, those have been chosen, which are generally regarded as the most simple; and new ones have been introduced, only when they appeared to be still more proper than the old ones, either for simplifying the calculations, or rendering the operations more uniform.

NOTE I.

*Calculation of the horary angle**.

We have generally, in the triangle Z P S,

$$\cos \text{ZPS} = \frac{\cos \text{ZS} - \cos \text{PZ}.\cos \text{PS}}{\sin \text{PZ}.\sin \text{PS}};$$

but Z P S $= h$, Z S $= 90^\circ - $ H, P Z $= 90^\circ - $ L, and P S $=$ D; we shall therefore have the following equation:

$$\cos h = \frac{\sin \text{H} - \sin \text{L}.\cos \text{D}}{\cos \text{L}.\sin \text{D}}.$$

According to the rules of trigonometry,

$$\cos h = 1 - 2 \sin^2 \tfrac{1}{2} h,$$

and

$$\sin \text{L}.\cos \text{D} = \sin (\text{L} + \text{D}) - \cos \text{L}.\sin \text{D}.$$

Substituting in the preceding equation their values for the $\cos h$, and the sin L.cos D, we shall have,

$$2 \sin^2 \tfrac{1}{2} h = \frac{\sin (\text{L} + \text{D}) - \sin \text{H}}{\cos \text{L}.\sin \text{D}}$$

But,

$$\sin (\text{L} + \text{D}) - \sin \text{H} = 2 \cos \tfrac{1}{2} (\text{L} + \text{D} + \text{H}).\sin \tfrac{1}{2} (\text{L} + \text{D} - \text{H});$$

from which it follows that

$$\sin^2 \tfrac{1}{2} h = \frac{\cos \tfrac{1}{2} (\text{L} + \text{D} + \text{H}).\sin \tfrac{1}{2} (\text{L} + \text{D} - \text{H})}{\cos \text{L}.\sin \text{D}.};$$

otherwise

$$\sin. \tfrac{1}{2} h = \left(\frac{\cos \left(\frac{\text{L} + \text{D} + \text{H}}{2}\right) \sin \left(\frac{\text{L} + \text{D} - \text{H}}{2} - \text{H}\right)}{\cos \text{L}.\sin \text{D}} \right)^{\frac{1}{2}}.$$

The rules in art. 75 are derived from this formula, which is

* See art. 75.

Borda's. The same number of logarithms are required as by the other methods; but the preparation for the calculation is rather more simple.

NOTE II.

*Calculation of the Altitude**.

THE EQUATION of the preceding problem,

$$\cos h = \frac{\sin \text{H} - \sin \text{L}.\cos \text{D}}{\cos \text{L}.\sin \text{D}},$$

gives us

$$\sin \text{H} = \sin \text{L}.\cos \text{D} + \cos h.\cos \text{L}.\sin \text{D};$$

but $\cos h = 2\cos^2 \tfrac{1}{2} h - 1$, and by substituting this value in the equation we have

$$\sin \text{H} = \sin \text{L}.\cos \text{D} + 2\cos^2 \tfrac{1}{2} h.\cos \text{L}.\sin \text{D} - \cos \text{L}.\sin \text{D};$$

or else

$$\sin \text{H} = 2\cos^2 \tfrac{1}{2} h.\cos \text{L}.\sin \text{D} - \sin (\text{D} - \text{L}).$$

But on the other hand,

$$\sin \text{H} = 1 - 2\cos^2 \tfrac{1}{2}(90^\circ + \text{H})$$

and

$$\sin (\text{D} - \text{L}) = 2\cos^2 \tfrac{1}{2}(90^\circ - \overline{\text{D} - \text{L}}) - 1.$$

Substituting these values in the preceding equation, we have

$$\cos^2 \tfrac{1}{2}(90^\circ + \text{H}) = \cos^2 \tfrac{1}{2}(90^\circ - \overline{\text{D} - \text{L}}) - \cos^2 \tfrac{1}{2} h.\cos \text{L}.\sin \text{D};$$

from which we obtain

$$\sin.\ \text{M} = \frac{\cos \tfrac{1}{2} h.(\cos \text{L}.\sin \text{D})^{\frac{1}{2}}}{\cos \tfrac{1}{2}(90^\circ - \overline{\text{D} - \text{L}})}$$

and

$$\cos \tfrac{1}{2}(90^\circ + \text{H}) = \cos \tfrac{1}{2}(90 - \overline{\text{D} - \text{L}}).\cos \text{M}.$$

* See art 80.

Borda has given, in his *Treatise on the Reflecting Circle*, the following formulæ for resolving the same problem.

$$\text{tang } M = \frac{\sin \frac{1}{2} h.(\cos L.\sin D)^{\frac{1}{2}}}{\sin \frac{1}{2}(90^\circ - L + D)},$$

and

$$\sin \tfrac{1}{2}(90^\circ - H) = \frac{\sin - (90^\circ - L + D)}{\cos M}.$$

It ought, however, to be observed that the sin $\frac{1}{2}(90^\circ - H) = \cos \frac{1}{2}(90^\circ + H)$; but the altitude is more easily found from $\frac{1}{2}(90^\circ + H)$ than from $\frac{1}{2}(90^\circ - H)$, and this is one of the advantages of the formula which has been adopted. Then, according to the present arrangement of the calculation, we likewise obtain the $\cos \frac{1}{2}(90^\circ - D - L).\cos M$ with greater facility than

$$\frac{\sin \frac{1}{2}(90^\circ - L + D)}{\cos M};$$

the method which we have adopted, therefore, simplifies the calculation a little.

NOTE III.

Calculation of Latitude from two Altitudes of the Sun taken out of the Meridian, and the interval of time between the observations.*

Let S, fig. 1, and 2, be the place of the sun where the observation of the less altitude is taken, S′ his place at the instant of the greater altitude. Suppose the two places of the sun to be joined by the arc of a great circle S S′; preserving the denominations that have been adopted, and denoting the greater altitude S′ I′ by H′, and, the interval of time between the observations, reduced into degrees by t. The angle S P S′, formed by the two circles of declination, P S and P S′, is equal to t, and the arc of the great circle S S′ is the distance of the two places of the sun.

This being supposed, in the triangle S P S′, which may be considered as isosceles for abridging the operations, calculate the

* See art. 67.

distance S S′, and the first angle at the sun P S S′ formed by this distance, and the circle of declination corresponding to the less altitude. In the triangle Z S S′, there are known the three sides, one of which is the distance of the two places of the sun, and the other two are the complements of the two observed altitudes; we can therefore calculate the second angle at the sun Z S S′, formed by the circle of the distance and the sun's vertical circle at the time of observing the less altitude. The difference of the two angles at the sun P S S′ − Z S S′, fig. 1, or their sum P S S′ + Z S S′, fig. 2, is the angle of variation Z S P of the triangle Z P S, which serves to calculate the side Z P, or the latitude.

Distance of the sun's places, and the first angle at the sun. If we suppose the two declinations to be the same, the sides P S and P S′ will be equal, and the triangle P S S′ will be isosceles; then, by the common rules of trigonometry, we have

$$\sin \tfrac{1}{2} \mathrm{S\,S'} = \sin \tfrac{1}{2} t . \sin \mathrm{D},$$

and

$$\operatorname{tang} \mathrm{P\,S\,S'} = \frac{\cot \tfrac{1}{2} t}{\cos \mathrm{D}}.$$

These are the two equations from which the distance S S′ and the first angle at the sun P S S′ are calculated.

Second angle at the sun. In the triangle Z S S′, we have the equation

$$\cos \mathrm{Z\,S\,S'} = \frac{\cos \mathrm{Z\,S'} - \cos \mathrm{Z\,S} . \cos \mathrm{S\,S'}}{\sin \mathrm{Z\,S} . \sin \mathrm{S\,S'}}.$$

If we employ the denominations that have been adopted, this will become

$$\cos \mathrm{Z\,S\,S'} = \frac{\sin \mathrm{H'} - \sin \mathrm{H} . \cos \mathrm{S\,S'}}{\cos \mathrm{H} . \sin \mathrm{S\,S'}};$$

but

$$\cos \mathrm{Z\,S\,S'} = 1 - 2 \sin^2 \tfrac{1}{2} \mathrm{Z\,S\,S'},$$

and

$$\sin \mathrm{H} . \cos \mathrm{S\,S'} = \sin (\mathrm{H} + \mathrm{S\,S'}) - \cos \mathrm{H} . \sin \mathrm{S\,S'}.$$

Substituting these values of the cos Z S S′, and sin H.cos S S′

in the preceding equation, and making the necessary reductions, we have

$$2 \sin^2 \tfrac{1}{2} \text{Z S S}' = \frac{\sin(\text{H} + \text{S S}') - \sin \text{H}'}{\cos \text{H}.\sin \text{S S}'}.$$

We have also

$$\sin(\text{H} + \text{S S}') - \sin \text{H}' = 2 \cos \tfrac{1}{2}(\text{H} + \text{S S}' + \text{H}').\sin \tfrac{1}{2}(\text{H} + \text{S S}' - \text{H}'),$$

therefore

$$2 \sin^2 \tfrac{1}{2} \text{Z S S}' = \frac{2 \cos \tfrac{1}{2}(\text{H} + \text{S S}' + \text{H}').\sin \tfrac{1}{2}(\text{H} + \text{S S}' - \text{H}')}{\cos \text{H}.\sin \text{S S}'};$$

or else

$$\sin \tfrac{1}{2} \text{Z S S}' = \left(\frac{\cos\left(\frac{\text{H} + \text{S S}' + \text{H}'}{2}\right)\sin\left(\frac{\text{H} + \text{S S}' + \text{H}}{2} - \text{H}'\right)}{\cos \text{H}.\sin \text{S S}'} \right)^{\frac{1}{2}}$$

This formula, by which the second angle at the sun is found, is analogous to that by which the horary angle is calculated. The given quantities should be disposed in the same manner, and the preparation for the calculation is as simple.

Latitude. The triangle Z S P gives us

$$\cos \text{P S Z} = \frac{\cos \text{Z P} - \cos \text{P S}.\cos \text{Z S}}{\sin \text{P S}.\sin \text{S Z}'},$$

$$\cos \text{V} = \frac{\sin \text{L} - \cos \text{D}.\sin \text{H}}{\sin \text{D}.\cos \text{H}},$$

from which we obtain

$$\sin \text{L} = \cos \text{V}.\sin \text{D}.\cos \text{H} + \cos \text{D}.\sin \text{H}.$$

It is known that cos. $\text{V} = 2 \cos^2 \tfrac{1}{2} \text{V} - 1$, and by substituting this value we have

$$\sin \text{L} = 2 \cos^2 \tfrac{1}{2} \text{V}.\sin \text{D}.\cos \text{H} - \sin(\text{D} - \text{H}):$$

but

$$\sin \text{L} = 1 - 2 \cos^2 \tfrac{1}{2} (90^\circ + \text{L}),$$

and

$$\sin(\text{D} - \text{H}) = 2 \cos^2 \tfrac{1}{2} (90^\circ - \text{D} - \text{H}) - 1.$$

Hence by the substitution of these two values of sin. L, and sin (D — H), we shall have

$$\cos^2 \tfrac{1}{2}(90^\circ + L) = \cos^2 \tfrac{1}{2}(90 - \overline{D - H}) - \cos^2 \tfrac{1}{2} V.\sin D.\cos H;$$

from which we derive

$$\sin M = \frac{\cos \tfrac{1}{2} V.(\sin D.\cos H)^{\frac{1}{2}}}{\cos \tfrac{1}{2}(90^\circ - \overline{D - H})},$$

and

$$\cos \tfrac{1}{2}(90^\circ + L) = \cos \tfrac{1}{2}(90^\circ - \overline{D - H}).\cos M.$$

This formula is analogous to that for calculating the altitude, and consequently possesses the same advantages.

NOTE IV.

Calculation of the true distance between the Moon and the Sun or a Star.*

Let Z be the zenith, fig. 3, ZH the moon's vertical circle, and ZO that of the sun. If L be the apparent place of the moon, and L′ the true place; also if S be the apparent place of the sun and S′ the true place, SL will be the apparent distance, and S′L′ the true distance. Call H the apparent altitude HL of the moon, and H′ the true altitude; B the apparent altitude of the sun, and B′ the true altitude; Δ the apparent distance, and x the true distance required.

This being supposed, in the triangle LZS, formed by the apparent distance of the two heavenly bodies, and the apparent zenith distance of each body, we have

$$\cos Z = \frac{\cos \Delta - \sin H.\sin B}{\cos H.\cos B}.$$

In the triangle L′ZS′ composed of the true altitudes and the true distance, we have

* See art 113.

$$\cos Z = \frac{\cos x - \sin H'.\sin B'}{\cos H'.\cos B'}.$$

therefore

$$\frac{\cos \Delta - \sin H.\sin B.}{\cos H.\cos B.} = \frac{\cos x - \sin H'.\sin B'}{\cos H'.\cos B'}.$$

but

$$\sin H.\sin B. = \cos H.\cos B - \cos (H + B),$$

and

$$\sin H'.\sin B' = \cos H'.\cos B' - \cos (H' + B').$$

Substituting these values of the sin H.sin B, and of sin H' sin B', we shall have

$$\frac{\cos \Delta + \cos (H + B)}{\cos H.\cos B} = \frac{\cos x + \cos (H' + B')}{\cos H'.\cos B'},$$

and

$$\cos x = \frac{\cos H'.\cos B'}{\cos H.\cos B}\left\{ \cos \Delta + \cos (H + B) \right\} - \cos (H' + B').$$

We know that

$$\cos \Delta + \cos (H + B) = 2 \cos \tfrac{1}{2} (H + B + \Delta) \cos \tfrac{1}{2} (H + B - \Delta),$$

$$\cos (H' + B') = 2 \cos^2 \tfrac{1}{2} (H' + B') - 1,$$

$$\cos x = 1 - 2 \sin^2 \tfrac{1}{2} x.$$

By substituting these values in the equation, we shall have

$$\sin^2 \tfrac{1}{2} x = \cos^2 \tfrac{1}{2} (H' + B') - \frac{\cos \tfrac{1}{2} (H + B + \Delta) \cos \tfrac{1}{2} (H + B - \Delta) \cos H'.\cos B'}{\cos H.\cos B.}.$$

Now making

$$\sin M = \frac{\left(\dfrac{\cos \tfrac{1}{2} (H + B + \Delta) \cos \tfrac{1}{2} (H + B - \Delta) \cos H'.\cos B'}{\cos H.\cos B.} \right)^{\frac{1}{2}}}{\cos \tfrac{1}{2} (H' + B')};$$

we shall have, lastly,

$$\sin \tfrac{1}{2} x = \cos \tfrac{1}{2} (H' + B').\cos M.$$

This formula is known by the name of *Borda's*; and is generally used when the tables of common logarithms only are employed.

NOTE V.

Calculation of the Sun's Azimuth and Amplitude. *

The triangle P S P, fig. 1, and 2, gives us the equation.

$$\cos \text{PZS} = \frac{\cos \text{PS} - \cos \text{PZ} . \cos \text{SZ}}{\sin \text{PZ} . \sin \text{SZ}},$$

or

$$\cos \text{A} = \frac{\cos \text{D} + \sin \text{L} . \sin \text{H}}{\cos \text{L} . \cos \text{H}};$$

but

$$\cos \text{A} = 2 \cos^2 \tfrac{1}{2} \text{A} - 1,$$

and

$$\sin \text{L} . \sin \text{H} = \cos \text{L} . \cos \text{H} - \cos (\text{L} + \text{H}).$$

Substituting these values of the cos A and the sin L.sin H, in the preceding equation, we have

$$2 \cos^2 \tfrac{1}{2} \text{A} = \frac{\cos \text{D} + \cos (\text{L} + \text{H})}{\cos \text{L} . \cos \text{H}}.$$

According to the known rules,

$$\cos \text{D} + \cos (\text{L} + \text{H}) = 2 \cos \tfrac{1}{2} (\text{D} + \text{L} + \text{H}) \cos \tfrac{1}{2} (\text{L} + \text{H} - \text{D}),$$

we have therefore

$$\cos^2 \tfrac{1}{2} \text{A} = \frac{\cos \tfrac{1}{2} (\text{D} + \text{L} + \text{H}) \cos \tfrac{1}{2} (\text{L} + \text{H} - \text{D})}{\cos \text{L} . \cos \text{H}},$$

or

$$\cos \tfrac{1}{2} \text{A} = \left(\frac{\cos \left(\frac{\text{D} + \text{L} + \text{H}}{2}\right) \cos \left(\frac{\text{D} + \text{L} + \text{H}}{2} - \text{D}\right)}{\cos \text{L} . \cos \text{H}} \right)^{\frac{1}{2}}$$

This formula is extracted from *Borda's* Treatise on the reflecting circle. It appears from inspection of figs. 1 and 2, that the angle P Z S is always formed by the vertical circle of the sun, and that part of the meridian adjacent to the elevated pole.

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* See art 132.

Thus the calculated azimuth A ought, in all cases, to be reckoned from the pole which is above the horizon, as has been observed in art. 132.

Let the equation be resumed,

$$\cos A = \frac{\cos D - \sin L . \sin H}{\cos L . \cos H}.$$

Suppose that the sun is in the horizon, then H becomes equal to nothing, cos H = 1, and we have,

$$\cos A = \frac{\cos D}{\cos L}.$$

If the declination d be employed instead of the polar distance, we have $\sin d = \cos D$. On the other hand $90° - A$ or $A - 90°$ is the amplitude of the heavenly body, we shall therefore have

$$\text{sine amplitude} = \frac{\sin d}{\cos L}.$$

This is the formula that has been employed in calculating the amplitude of the sun. (*See* art. 136.)

The rules which have been given in art. 146, for calculating the sun's azimuth by means of the horary angle, and derived from Napier's two well known analogies, which serve to calculate one of the angles of a spherical triangle, when two sides and their contained angle are given. In effect, in figs. 1, and 2, in the triangle PZS, knowing the angle $ZPS = h$, the side $PZ = 90° - L$ and the side $PS = D$, we have

$$\text{tang } \tfrac{1}{2}(A \sim V) = \cot \tfrac{1}{2} h \frac{\sin \tfrac{1}{2}(\overline{90° - L} \sim D)}{\sin \tfrac{1}{2}(\overline{90° - L} + D)}$$

and

$$\text{tang } \tfrac{1}{2}(A + V) = \cot \tfrac{1}{2} h \frac{\cos \tfrac{1}{2}(\overline{90° - L} \sim D)}{\cos \tfrac{1}{2}(\overline{90° - L} + D)}.$$

When the sun passes the meridian towards the depressed pole, fig. 1, A is greater than V, and we shall have

$$A = \tfrac{1}{2}(A - V) + \tfrac{1}{2}(A + V),$$

that is, the azimuth is equal to the sum of the first and second angles.

If the sun pass the meridian towards the elevated pole, fig. 2, A is, on the contrary, less than V, and we shall have

$$A = \tfrac{1}{2}(A + V) - \tfrac{1}{2}(V - A),$$

that is, the azimuth is equal to the difference of the first and second angles. It ought to be understood, by inspection of figs. 1 and 2, that the angle A is always reckoned, as in the preceding calculation, to commence at the elevated pole.

NOTE VI.

*Calculation of the difference between the Azimuth of the Sun and the Azimuth of a terrestrial object.**

Let S be the sun's apparent place, M the summit of the mountain of which the distance S M from the sun has been observed. Let the apparent distance S M be denoted by Δ; the apparent altitude S H of the sun by H; and the apparent altitude of the object M, by O; also let Z be the difference of the azimuths, or the angle S Z M. In the triangle Z S M, we have

$$\cos SZM = \frac{\cos SM - \cos ZS.\cos ZM}{\sin ZS.\sin ZM.},$$

or otherwise,

$$\cos Z = \frac{\cos \Delta - \sin H.\sin O}{\cos H.\cos O};$$

but

$$\cos Z = 2\cos^2 \tfrac{1}{2} Z - 1,$$

and

$$\sin H.\sin O = \cos H.\cos O - \cos (H + O).$$

Substituting these values, we have

$$2\cos^2 \tfrac{1}{2} Z = \frac{\cos \Delta - \cos (H + O)}{\cos H.\cos O}.$$

* See art. 142.

According to the rules of trigonometry,

$$\cos\Delta - \cos(\text{H}+\text{O}) = 2\cos\tfrac{1}{2}(\Delta+\text{H}+\text{O}).\cos\tfrac{1}{2}(\text{H}+\text{O}-\Delta),$$

we shall therefore have

$$\cos^2\tfrac{1}{2}z = \frac{\cos\frac{1}{2}(\Delta+\text{H}+\text{O}).\cos\frac{1}{2}(\text{H}+\text{O}-\Delta)}{\cos\text{H}.\cos\text{O}},$$

and finally

$$\cos\tfrac{1}{2}z = \left(\frac{\cos\left(\frac{\Delta+\text{H}+\text{O}}{2}\right)\cos\left(\frac{\Delta+\text{H}+\text{O}}{2}-\Delta\right)}{\cos\text{H}.\cos\text{O}}\right)^{\frac{1}{2}}.$$

This last formula is *Borda's*; it is analogous to that which serves for calculating the sun's azimuth by means of his altitude. The quantities that are required to obtain the astronomical bearing of any object from it, may therefore generally be found by two calculations very nearly similar.

NOTE VII.

Principles of the construction of the Tables for finding the correction of the less of two altitudes, taken out of the meridian, in order to find the latitude.

Let A be the azimuth, L the latitude, and H the altitude of the sun. If δH be the change in altitude answering to a small change in latitude δL, we have, by the known rules, $\delta\text{H} = \mp\,\delta\text{L}.\cos\text{A}$; the sign *minus* is to be used when the sun passes the meridian towards the depressed pole, and the sign *plus* when he passes it towards the elevated pole. In fact, in the first case, fig. 1, the angle A is greater than 90°, and its cosine is negative; in the second case, fig. 2, the angle A is less than 90°, and its cosine is positive. Now, if the effect which the change of latitude ought to produce upon the meridian altitude of the sun be considered, it will be seen that the errors in altitude, when the sun is above the meridian, take place in the same sense as those of the meridian altitudes; hence, if the azimuth A be reckoned to commence at the side where the sun passes the meridian, we

shall always have $\delta H = diff. merid. alt. \times \cos A$. When the change in latitude increases the meridian altitude, the value of δH must be added to the observed altitude, and subtracted in the contrary case. When it is greater than 90°, the cosine of A becomes negative; then δH should be employed with a different sign from that of the variation of the meridial altitude. This last distinction of case may be made to disappear, by employing for the cos A its value $1 - \text{vers } A$, and we shall have $\delta H = diff. merid. alt. - diff. merid. alt. \times \text{vers } A$. When A is less than 90°, the versed sine of A will be less than unity, and the correction will be positive. When it is greater than 90°, the vers. A will be greater than unity, and the correction will be negative. Tables XII and XIII are intended to calculate the versed sine of A, supposing this angle, as already observed, to be reckoned from the side on which the sun passes the meridian.

Instead of the polar distance which has hitherto been used, the declination of the sun may be employed, and let d = this element. The triangle PZS, fig. 15, gives

$$\cos A = \frac{\sin D - \sin L . \sin H}{\cos L . \cos H},$$

$$\text{vers } A = \frac{\cos (L \sim H) - \sin d}{\cos L . \cos H}.$$

When the declination is of a different denomination from the latitude, the sin d changes its sign; we shall therefore have generally

$$\text{vers } A = \frac{\cos (L \sim H)}{\cos L . \cos H} \mp \frac{\sin d}{\cos L . \cos H}.$$

The upper sign takes place when the declination is of the same denomination as the latitude, and the lower sign when the denominations are different.

The left hand page of Table XII, contains the first term $\frac{\cos (L \sim H)}{\cos L . \cos H}$; this table must be entered with the latitude L, and the altitude H. The right-hand page contains, under the term

argument the value of the denominator cos L. cos H; and it is with the argument and the declination that we find, in table XIII, the value of the second term $\dfrac{\sin d}{\cos \text{L}.\cos \text{H}}$.

The angle A which is obtained from the preceding formula, by calculation, is to be reckoned from the elevated pole, but according to what has been said, the azimuth should be reckoned, in all cases, from the side on which the sun passes the meridian, which is sometimes that of the elevated, and sometimes that of the depressed pole; this is done in the following manner.

For the sake of abridgment, make

$$\frac{\cos(\text{L} \sim \text{H})}{\cos \text{L}.\cos \text{H}} = \text{P} \quad \text{and} \quad \frac{\sin d}{\cos \text{L}.\cos \text{H}} = \text{S},$$

we shall then have vers $\text{A} = \text{P} \mp \text{S}$.

If the declination and the latitude be of the same name, and the declination greater than the latitude, the sun passes the meridian towards the elevated pole: then we have

$$\text{vers A} = \text{P} - \text{S}.$$

When P and S have been found by the rules in art. 40, the second term must be subtracted from the first

In the case in which the latitude is greater than the declination, the sun passes the meridian towards the depressed pole, and the versed sine of the azimuth, reckoned from this pole, is 2 — vers A: we have therefore

$$2 - \text{vers A} = 2 - \text{P} + \text{S} = (2 + \text{S}) - \text{P}.$$

The first term must be subtracted from the second increased by 2 units; as before specified.

When the declination has a denomination different from the latitude, the sun passes the meridian towards the depressed pole, and we shall have

$$2 - \text{vers A} = 2 - \text{P} - \text{S} = (2 - \text{S}) - \text{P}.$$

In the second part of Table XIII, in which the declination

and latitude are of different kinds, we have to write 2 — s instead of s: by this means, the first term must be subtracted from the second, but it is not necessary to increase the second term by two units.

What we have called the multiplier of the way made in latitude is, therefore, the versed-sine of the sun's azimuth reckoned from that side on which his passage over the meridian takes place: the arc which corresponds to this versed-sine is found in Table XIV.

Tables XII and XIII may also be used for correcting the altitudes observed at the same time as the distance of the moon from the sun or a star is taken, in the case in which the reduced distance of the two bodies is required on the hypothesis that the earth is an oblate spheriod. According to what has been said in art. 122, it is sufficient to calculate the altitudes with the latitude of the place where the distance was observed, diminished by the angle at the vertical. Hence, if the altitudes have been obtained directly from observation, there must be added to, or subtracted from them, the quantities by which they ought to be increased or diminished, on account of the decrease in latitude, which will be equal to the angle at the vertical. In order to render the use of Tables XII and XIII uniform, it will be necessary to consider whether a diminution in the latitude of the place where the distance is observed, tends to augment or diminish the meridian altitude of the heavenly body, the altitude of which is to be corrected. Then, the operations, relative to the angle at the vertical, are performed in the same manner as recommended with respect to the change of latitude which takes place between the observations of the altitudes taken out of the meridian, in order to ascertain the latitude. There will, in this case, be obtained, the corrected altitudes, by which the true distance of the bodies is found, on the hypothesis of the earth being a spheroid flattened at the poles.

NOTE VIII.

Means of calculating the inclination of the visual ray meeting the Shore by which the Horizon is bounded.

Let A O, fig. 5, be a portion of the earth's surface, and A the point of the shore which bounds the horizon where the vertical circle of a heavenly body meets it. If from the point B, which is elevated by a quantity equal to B O, the altitude of that body be observed, and its reflected image be brought to coincide with the point A, the inclination of the visual ray B A, which it is required to find, will be equal to the angle L B A, which this visual ray makes with the horizontal line L B. When the distance A B, or arc A O, is unknown, the angle L B A must be obtained as follows.—While one person observes the altitude of the body at the point B, another is to observe the altitude of the same body from b, at a much greater elevation than B; the difference of the two heights b O and B O, as well as that of the two observed angles will serve to find the angle L B A.

Let I denote the angle L B A, or the correction of the observed altitude at B, and I′ the angle $l b$ A, or the correction of the altitude observed at b. Let h be the elevation of the eye, B O, and h' the elevation b O. Draw A D perpendicular to the radius C O, which is produced to b. This being supposed, the right angled triangles b A D, B A D, by the rules of trigonometry, give the two following equations:

$$\cot \mathrm{A}b\mathrm{D} = \operatorname{tang} \mathrm{I}' = \frac{b\,\mathrm{D}}{\mathrm{A\,D}},$$

$$\cot \mathrm{ABD} = \operatorname{tang} \mathrm{I} = \frac{\mathrm{B\,D}}{\mathrm{A\,D}};$$

from which we obtain

$$\operatorname{tang} \mathrm{I}' - \operatorname{tang} \mathrm{I} = \frac{b\,\mathrm{D} - \mathrm{B\,D}}{\mathrm{A\,D}}.$$

The angles I′ and I never exceed a very small number of minutes; we shall therefore have, without sensible error*,

$$\sin 1'' (I' - I) = \frac{h' - h}{AD},$$

and

$$AD = \frac{h' - h}{\sin 1'' (I' - I)};$$

but

$$\text{tang } I = \frac{BD}{AD} = \frac{BO + DO}{AD} = \frac{h + DO}{AD}.$$

On the other hand, tang $I = \sin 1'' \times I$, very nearly, we shall therefore have

$$I = \frac{h}{\sin 1''.AD} + \frac{DO}{\sin 1''.AD}.$$

It ought to be remarked that DO is the versed-sine of the arc AO, of which the sine AD is known; we must therefore substitute for DO its value in a function of AD.

Supposing the radus equal to unity. we have, by the known rules,

$$\text{vers } AO = \frac{AO^2}{2} - \frac{AO^4}{24},$$

and

$$AO = \sin AO + \frac{\sin^3 AO}{24}.$$

Substituting the value of AO, given by the second equation, in the expression for the versed-sine of AO, we shall have, by neglecting the terms above the fourth powers,

$$\text{vers } AO = \frac{\sin^2 AO}{2} + \frac{3 \sin^4 AO}{24}.$$

Let a be the radius of the earth, and substitute DO in the

* This supposition is so much the more admissible as it is only required to find the angle I to within some seconds of the truth

preceding equation instead of the vers A O, and A D instead of the sin A O, and we shall have

$$\text{D O} = \frac{\text{A D}^2}{2a} + \frac{5\,\text{A D}^4}{24\,a^3}.$$

But we already have the equation

$$\text{I} = \frac{h}{\sin 1''.\text{A D}} + \frac{\text{D O}}{\sin 1''.\text{A D}};$$

substitiuting here the value of D O, and it will give

$$\text{I} = \frac{h}{\sin 1''.\text{A D}} + \frac{\text{A D}}{2\,a.\sin 1''} + \frac{\text{A D}^3}{8\,a^3.\sin 1''};$$

but

$$\text{A D} = \frac{h' - h}{\sin 1''\,(\text{I}' - \text{I})},$$

the preceding equation therefore becomes

$$\text{I} = \frac{h\,(\text{I}' - \text{I})}{h' - h} + \frac{h' - h}{2\,a.\sin^2 1''.\,(\text{I}' - \text{I})} + \frac{(h' - h)^3}{8\,a^3.\sin^4 1''.\,(\text{I}' - \text{I})^3}.$$

The value of the third term of this equation will always be insensible, and we may, in all cases, confine ourselves to the calculation of the first two; we shall therefore have

$$\text{I} = \frac{h\,(\text{I}' - \text{I})}{h' - h} + \frac{h' - h}{2\,a.\,\sin^2 1''.(\text{I}' - \text{I})}.$$

The first term may be calculated by a simple rule of proportion. As to the second, it would be easy to construct a small table of two arguments; and with the difference of the two heights of the eye, and the difference of the observed angles, it might be found, without being obliged to take proportional parts. The second term might also include the advantage of enabling us to correct the inclination of the visual ray B A for the effect of terrestrial refraction; for we have

$\sin \text{A O} = \sin 1''.\,\text{A O}$; from which $\text{A O} = \dfrac{\sin \text{A O}}{\sin 1''}$, or

$\text{A O} = \dfrac{\text{A D}}{\sin 1''}$. If it be wished to have A O in parts of the circum-

ference, AD must be used in parts of the radius; then we have $AO = \frac{AD}{a . \sin 1''}$, or else $AO = \frac{h' - h}{a . \sin^2 1'' . (I' - I)}$; from which it follows that the second term of the value of the depression I, is always equal to half the terrestrial arc comprised between the observer and the point of the shore to which the reflected image of the sun is brought: hence we might subtract from this half, the necessary quantity to have the refraction corresponding to the whole arc.

Resume the equation from which the value of I has been obtained.

$$I = \frac{h(I' - I)}{h' - h} + \frac{1}{2\, a . \sin^2 1''} \times \frac{(h' - h)}{(I' - I)}.$$

By adopting the differential method, and regarding I and $(I' - I)$ as variable quantities, we shall have

$$\delta I = \delta(I' - I)\, \frac{h}{(h' - h)} - \delta(I' - I)\, \frac{(h' - h)}{2\, a . \sin 1'' . (I' - I)^2}.$$

The error of the first term will be less as $h' - h$ is greater, or as the point h' is more elevated. The contrary will take place with respect to the second term: but as this term has a contrary sign to the first, the value of the error of I will be, in all cases, diminished by that with which this term is affected. It may therefore be concluded, in the first place, that the second term must never be neglected; and, in the second, that one of the altitudes should be observed in a very elevated situation. One of the observers should therefore be placed upon the deck of the vessel, and the other at the top of one of its masts; then the quantity $\frac{h}{h' - h}$ may be equal to $\frac{1}{5}$ or $\frac{1}{6}$, and the error of the angle I will always be less than $\frac{1}{5}\, \delta(I' - I)$ or $\frac{1}{6}\, \delta(I' - I)$.

The altitude observed at the lower station may be obtained within about $1'$; but the observer placed at the top mast, where the motion of the vessel is more sensible, frequently cannot observe the altitude within less than $3'$ or $4'$. It may therefore be supposed

that the error of $I' - I$ is $4'$; then that of the angle I, or of the depression which would be obtained from the calculation, would be $\frac{4}{5}$ or $\frac{4}{6}$ of a minute, which is equal to $48''$ or $40''$. Whenever the distance from land exceeds a league, there will not be much advantage in using this method. And it ought to be perceived that it must never be employed in determining geographical positions.

The circumstances which it appears at first ought to be most advantageous, are those in which the vessel is at least two miles from the shore; now $(I' - I)$ will then become greater, the error increases in proportion, and may even be more than a minute. On the other hand, at a small distance from land, the undulations of the shore become sensible, and the two observers would be exposed to the inconvenience of referring their images of the sun to two different points, which might both be out of the vertical circle of the sun. It is difficult to value the errors with which $I' - I$, and the altitude itself, might be affected, in this case; we only know that they might be very considerable, and render the results very defective. It was chiefly this last cause which induced us not to give, in the preceding treatise, the method of correcting altitudes observed near land, by simultaneous observations made at very different elevations. Besides, it appears that the difficulty of taking observations in places so elevated as the top-masts of a vessel, has deterred navigators; and they make very little use of this method: they prefer removing from the shore, as has been recommended, when they wish to obtain altitudes upon which they can depend.

APPENDIX.

CONTAINING a series of practical Examples adapted to the various Rules given in the preceding treatise; and designed to assist the young Mariner in obtaining a knowledge of this important part of practical Navigation, by furnishing him with a copious collection of exercises on the subject of Nautical Astronomy.

PRACTICAL EXAMPLES TO

CHAPTER I.

Conversion of Longitude into Time. Arts. 11 *and* 12.

Example 1.

Required the time answering to 97° 55′ 39″ of longitude.

$$\begin{array}{lr} & 97^\circ\ 55'\ 39'' \\ \text{Multiply by - - - -} & 4 \\ \hline \text{Product -} & 6^h\ 30'\ 42''\ 36''' \end{array}$$

Then by dividing the thirds by 6, gives $36''' \div 6 = \cdot 6''$, the decimal of a second; and therefore $6^h\ 30'\ 42''\cdot 6$ is the time required.

Example 2.

What is the time corresponding to 141° 13′ 51″ of longitude.

Ans. $9^h\ 24'\ 55''\cdot 4$

Example 3.

Reduce 76° 43′ 27″ of longitude into time.

Ans. 5^h 6′ 53″·8.

Example 4.

What are the hours, minutes, and seconds, corresponding to 187° 54′ of longitude? Ans. 9^h 10′ 36″.

Conversion of Time into Longitude. Arts, 13 *and* 14.

Example 5.

What is the longitude corresponding to 7^h 54′ 32″·8 of time?

Multiplying the tenths of a second by 6, to obtain the thirds, gives ·8 × 6 = 48‴, then

Dividing by 4)	54′ 32″ 48‴
Quotient -	13° 38′ 12″
15 × 7	= 105
Longitude required	118° 38′ 12″

Example 6.

Find the longitude answering to 6^h 44′ 10″ of time.

Ans. 101° 2′ 30″.

Example 7.

What longitude corresponds to 2^h 3′ 17″·8?

Ans. 30° 49′ 27″.

Example 8.

If the time elapsed be 57′ 43″·3, what is the corresponding longitude? Ans. 14° 25′ 49″½.

Declination of the Sun. Art. 16.

Let T denote the time between the epoch in the Nautical Almanac preceding and that following the time for which the quantity is to be calculated; and t, the time between the first epoch and the given time. Also let Q express the quantity in the Almanac, answering to the first epoch, and q the change corres-

ponding to the time T; then $T : t :: q : \frac{q \times t}{T}$ = the change answering to the time t; and consequently the quantity required will be equal to

$$\underset{\text{noon}}{Q} \pm \frac{q \times t}{T};$$

where the sign + is generally used when the quantity Q is increasing, and the sign — when it is decreasing. This simple formula may easily be remembered, and will render it unnecessary to refer to any written rule.

Example 9.

What was the sun's declination on the 12th of January, 1814, at 10ʰ 20′ in the morning, civil time, in west longitude 63° 42′?

First, 63° 42′ = 4ʰ 14′ 48″, the time that the sun passes the meridian of 63° 42′ of west longitude *after* it has passed that of Greenwich; therefore when it is 10ʰ 20′ in the morning at the former place, it is 10ʰ 20′ + 4ʰ 14′ 48″ = 14ʰ 34′ 48″, or 2ʰ 34′ 48″ after noon, civil time, at the latter. But as the astronomical day commences at noon, the required declination is for the 12th of January at 2ʰ 34′ 48″, astronomical time.

Sun's declination 12th Jan. 1814, at noon.	-	21° 42′ 16″
Ditto - - 13th - (*Subtract.*)	-	21 32 21
Decrease of declination in 24 hours	- -	0° 9′ 55″

By proportional parts, and taking only tenths of a second	In 2	- - -	0′ 49″·6
	30′	- -	0 12·4
	3	- -	0 1·2
	1	- -	0 0·4
	48″	-	0 0·3
	2ʰ 34′ 48″		1′ 3″·9

or 1′ 4″ nearly.

The same result may also be obtained by the following proportion.

As $24^h : 2^h\ 34'\ 48'' :: 9'\ 55'' : 1'\ 3''\cdot 91$,* or $1'\ 4''$ nearly.

Now as the declination is *decreasing*, this quantity must be subtracted from the sun's declination on the 12th at noon; hence

The declin. of sun, 12th Jan. at noon, second	-	21° 42′ 16″
Decrease in $2^h\ 34'\ 48''$ - -	(subtract.)	1 4
DECLINATION required - -	South.	21° 41′ 12″

By the preceding formula,

$$\frac{2^h\ 34'\ 48'' \times 9'\ 55''}{24} = \frac{2^h\cdot 58 \times 9'\cdot 92}{24} = (\cdot 43 \times 2'\cdot 48) = 1'\ 3''\cdot 98.$$

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* As it is troublesome to multiply the second and third terms of this proportion together, on account of the different denominations they contain, the operation will be facilitated by reducing the lower denominations in the second term to decimals of an hour, and those in the third to decimals of the highest denomination it contains; and then the answer, or fourth term, will be of the same name as the third. This reduction is very easily made by dividing each lower denomination by 6 and annexing the quotient as decimals to the next higher.

$$\text{Thus } 34' + \frac{48}{6} = 34'\ 8, \text{ and } 2^h\ 34'\ 8 = 2^h + \frac{34'\ 8}{6} = 2^h\cdot 58,$$

$$\text{and } 9'\ 55'' = 9' + \frac{55}{6} = 9'\cdot 92 \text{ very nearly.}$$

Therefore $24^h : 2^h\cdot 58 :: 9'\ 92 : 1'\ 3''\ 98$, as before.

As some mariners may prefer the method of obtaining the fourth term of the proportion by the use of logarithms, with which they are so familiar, especially when it is thought necessary to retain three or four decimal places in either of the factors, it is proper to observe, that this may be expeditiously done by the following simple rule; viz.

Add the logarithms of the second and third terms to the constant logarithm —2·6197888, when the quantities in the Nautical Almanac are calculated for every 24 hours, but to —2·9208188, when they are calculated for every 12 hours. Thus, in the above example,

Constant Logarithm			-	—2·6197888
Logarithm of	-	2·58	-	0·4116197
Ditto of	-	9·92	-	0·9965117
Nat. Numb. 1′ 0664 = 1′ 3″·98				0.0279202

or 1′ 4″ nearly, and 21° 42′ 16″ − 1′ 4″ = 21° 41′ 12″ S, the declination required.

NOTE. The tables usually given for correcting the declinations of the sun and moon, found in the Nautical Almanac for noon or midnight, for any other time of the day, and for finding the time of the moon's passage over any other meridian than that of Greenwich, generally require the proportional parts to be calculated, in order to obtain a near approximation. Thus, in the preceding example the use of Table VI, in the *Requisite Tables*, requires a double entry of the table, two subtractions, with one calculation for the proportional parts, and would have required two if the minutes in the time had not consisted of tens only. It is therefore frequently much better to find the whole correction at once by calculation; which may generally be done with great facility by regarding the formula $\frac{q \times t}{T}$ as a fraction, and cancelling both its terms by their common factors, as above. Besides, this method possesses the advantage of accuracy arising from calculating the correction from the actual variation for the day on which it is required; for the daily change in the sun's declination on the corresponding days in the several quarters is not the same. Taking a promiscuous example, the four corresponding days in the table above referred to, are February 23rd, May 18th, August 24th, and October 18th. The variations in the declination of the sun between noon on each of these days and the following noon, as given in the Nautical Almanac for 1814, are 22′ 3″, 13′ 10″, 20′ 34″ and 11′ 51″ respectively. The mean of these four is 16′ 54″½, which differs from each of them respectively by 5′ 8″½, 3′ 44″½, 3′ 39″½ and 5′ 3″½.

In the above example, the correction resulting from the use of the table is 1′ 0″·92, but the accurate correction from the calculation is 1′ 3″·98; the difference of which is therefore 3″·06. Hence, whenever accuracy is required, the correction should *always* be calculated from the actual variation on the day for which it is required.

Example 10.

On the 10th of March, 1814, being in longitude 54° 37′ East; what was the declination of the sun at the time of his passing the meridian? Ans. 4° 17′ 8″S.

Example 11.

Being in East longitude 121° 35′·6, by account, at 8^h 57′ 35″ A.M. on the 26th of October, 1814, civil time; required the sun's declination at that moment. Ans. 12° 10′ 34″S.

Example 12.

Required the declination of the sun at 4^h 50 minutes P.M. on the 15th of May, 1815, civil time, in 76° 43′ 27″ West longitude. Ans. 18° 49′ 24″N.

Declination of the Moon. Art. 16.

Example 13.

Required the moon's declination on the 20th of March, 1815, at 3 P.M. civil time, in longitude 134° 38′·4 East.

First, 134° 38′·4 = 8^h 58′ 33″·6 of time, which must be subtracted from the time in the question, as the place is east of the first meridian; and therefore, the hour reckoned from the commencement of the civil day is $3^h + 12^h - 8^h$ 58′ 33″·6 = 6^h 1′ 26″·4 A.M. But as the astronomical day begins 12 hours after the civil, the 20th of March has not yet commenced, and the astronomical time is the 19th of March at 18^h 1′ 26″·4: hence,

Moon's declination at midnight, 19th March,	N.	-	23°	2′
Ditto - - at noon, 20th -	N.	-	22	35
Decrease of declination in 12 hours. -	*Difference*	-	0	27

Then, as 12^h : 6^h 1′ 26″·4 : : 27′ : 13′ 33″·1, the change of declination corresponding to 6^h 1′ 26″·4; consequently,

At midnight - -	23°	2′	
Decrease - - -	13	33″·1	
DECLINATION required -	22°	48′	26″·9
Taking the nearest second	22	48	27

Example 14.

Required the moon's declination at the time of her rising at the Royal Observatory, Greenwich, on the 30th of October, 1814, which is 6^h 11′ A. M. civil time. Ans. 14° 32′ 51″N.

Example 15.

Required the moon's declination on the 17th of May, 1814, at 2^h 57′½ P.M. civil time, in 137° 54′ of West longitude?

Ans. 7° 52′ 40″N.

Example 16.

Required the moon's declination on the 28th of June, 1814, at the time of her setting at Greenwich, which is 1^h 29′ A. M. civil time? Ans. 11° 40′ 5″S.

Right Ascension of the Sun. Art. 16.

Example 17.

Required the right ascension of the sun on the 22nd of February, 1814, at 11^h 44′ P.M. civil time, in longitude 55° 25′ 12″ West of the meridian of Greenwich.

First, 55° 25′ 12″ of longitude converted into time gives 3^h 41′ 40″·8, which must be added to the time at the place of observation to obtain the hour at the first meridian, because the longitude is *west*; hence, the astronomical time, reduced to the first meridian, is the 22nd, at 3^h 25′ 40″·8.

Sun's right ascen. in time 22nd, at noon	-		22^h 20′ 56″·1
Ditto - - -	23rd, - - -	-	22 24 44·6
Increase in 24 hours - - - - -	-		0^h 3′ 48″·5

Then, as 24^h : 3^h 25′ 40″·8 : : 3′ 48″·5 : 32″·6, taking only one decimal place in the fourth term; consequently, as the right ascension is increasing,

Right ascension at noon, 22nd Feb. -		$22^h\ 20'\ 56''\cdot1$
Increase in $8^h\ 25'\ 40''\cdot8$ -	*(Add.)*	$32\cdot6$
RIGHT ASCENSION, in time, required -		$22^h\ 21'\ 28''\cdot7$
		or, 22 21 29 nearly.

Example 18.

What was the right ascension of the sun on the 3rd of May, 1814, at $3^h\ 36'\ 20''$ P.M. civil time, in longitude $120°\ 54'\cdot7$ East from Greenwich? Ans. $2^h\ 39'$.

Example 19.

Required the sun's right ascension at the time of his rising at Greenwich, on the 26th of November, 1814, which is at $7^h\ 31'$ civil time. Ans. $16^h\ 5'\ 48''\cdot1$.

Example 20.

Required the right ascension of the sun at the moment of his passage over the meridian of Port Royal, in Jamaica, situated in West longitude $76°\ 50'\ 30''$, on the 12th of August, 1815. Ans. $9^h\ 25'\ 54''\cdot8$.

Right Ascension of the Moon. Art. 16.

Example 21.

What was the right ascension of the moon on the 26th of April, 1814, at $9^h\ 50'$ P.M. civil time, in $39°\ 13'$ East longitude from Greenwich?

First, $39°\ 13' = 2^h\ 36'\ 52''$, which must be subtracted from $9^h\ 50'$, which gives $7^h\ 13'\ 8''$ for the time reduced to the first meridian, or that for which the right ascension is required. Then,

Moon's right ascension, 26th April, at midnight -	$128°\ 39'$
Ditto - - 26th, - at noon -	$121\ \ 16$
Increase in right ascension in 12 hours - -	$7°\ 23'$

By proportional parts, and taking only tenths of a minute.

In 6 hours	- - -	3° 41'·5
1	- - -	36·8
10'	- - -	6·1
2	- - -	1·2
1	- - -	·6
8"	- - -	·1
7h 13' 8"	- -	4° 26'·3

Hence, right ascension at noon   121° 16'
Increase in 7^h 13' 8" - *Add.* -   4 26·3

Right Ascension required -   125° 42'·3

Example 22.

Required the moon's right ascension on the 21st of July, 1814, at 9^h 57' A.M. civil time, at a place situated 35° 20' West of Greenwich. Ans. 177° 55'.

Example 23.

Required the right ascension of the moon on the 15th of January, 1815, at midnight, in 56° 38' of East longitude.

Ans. 354° 49'.

Example 24.

Required the moon's right ascension, at the time of her rising at Greenwich, on the 30th of December, 1814, which is 8^h 36' P.M. Ans. 156° 27' 27".

Semi-diameter of the Sun. Art. 16

Example 25.

What was the semi-diameter of the sun on the 31st of January, 1814?

Semi-diameter, Jan. 25th	-	16' 16"·2
Ditto Feb. 1st,	-	16' 15"·3
Decrease in 7 days	- -	0' 0"·9

Therefore $16' \; 16''\cdot2 - \frac{\cdot9'' \times 6}{7} = 16' \; 16''\cdot2 - \cdot8 = 16' \; 15''\cdot4$, the SEMI-DIAMETER required.

Example 26.

What was the sun's semi-diameter on the 29th of July, 1814, at 4^h A.M.? Ans. $15' \; 47''\cdot1$.

Example 27.

Required the sun's semi-diameter on the 17th of March, 1815. Ans. $16' \; 5''\cdot4$.

Example 28.

Required the semi-diameter of the sun on the 9th of November, 1815, at noon, in 180° of longitude? Ans. $16' \; 11''\cdot1$.

Semi-diameter of the Moon. Art. 16.

Example 29.

What was the moon's semi-diameter on the 16th of April, 1814, at $1^h \; 45'$, P.M. civil time, in East longitude 43° 21', supposing her altitude to be 26°?

$43° \; 21' = 2^h \; 53' \; 24''$; therefore the time in the question reduced to the first meridian is $10^h \; 51' \; 36''$ A.M. 16th April, civil time, or $22^h \; 51' \; 36''$, 15th April, astronomical time. Therefore,

Moon's semi-diam. 15th midnight	-	15′ 21″
Ditto - - 16th noon	-	15 28
Increase in 12 hours - -	-	0′ 7″
Then, as $12^h : 10^h \; 51' \; 36'' :: 7''$:	-	0′ 6″·3
Semi-diameter 15th midnight	-	15 21
Hor. Semi-diam. - -	-	15 27·3
Augmentation in TABLE II.	-	- 7
SEMI-DIAMETER required -	-	15′ 34″·3

Example 30.

Required the horizontal semi-diameter of the moon when she

passed the meridian of the Royal Observatory, at Greenwich, on the 20th of July, 1814. Ans. 16′ 7″.

Example 31.

Find the moon's horizontal semi-diameter on the 25th of January, 1815, at 2h 41′ P.M. civil time, in longitude 85° 56′ West. Ans. 16′ 45″

Example 32.

On the 8th of May, 1815, at 6^h 38′ A.M. by a chronometer regulated to civil time at the first meridian, suppose the moon's altitude found by observation to be 49° 30′; required her semi-diameter. Ans. 15′ 51″.

Moon's horizontal Parallax. Art. 16.

Example 33.

Required the moon's horizontal parallax on the 20th of May, 1814, at 5^h 45′ A.M. civil time, in latitude 55° N. and longitude 64° 34′ West.

Given time - - - - -		5^h	45′	
Longitude West, in time - *Add.*		4	17	36″
Time reduced to the first merid.		10^h	2′	36″

Moon's horizontal parallax, 19th at midnight -	60′	49″
Ditto - - - - 20th at noon -	60	55
Increase in 12 hours - - - - -	0′	6″

Then $60'\ 49'' + \dfrac{10^h\ 2'\ 36'' \times 6''}{12^h} = 60'\ 49'' + 5'' = 60'\ 54''$, which is the horizontal parallax at the equator at the given time; and which reduced, by Table III, to that at the latitude of the question, gives 60′ 46″ for the horizontal parallax required.

Example 34.

Required the moon's horizontal parallax at the time of her setting at Greenwich on the 13th of December, 1814; or at 5^h 23′ P.M. civil time. Ans. 53′ 59″.

Example 35.

The horizontal parallax of the moon is required for the 12th of March, 1815, at 7^h 20′, P.M. civil time, in latitude 54° 20′, and longitude 135° 38′ East. Ans. 55′ 51″.

Example 36.

Find the moon's horizontal parallax on the 28th of August, 1815, at 3^h 50′ A.M. civil time, in latitude 35° 10′, and longitude 72° 43′ West. Ans. 57′ 40″.

Moon's passage over the Meridian. Art. 16.

Example 37.

What time did the moon pass the meridian of 30° 45′ West longitude on the 25th of January, 1814?

Moon passed the first meridian 26th at		3^h 54′ P.M.	
Ditto - - - - 25th		3 7	
	Difference	0^h 47′	

Therefore 360° : 30°·75 : : 47′ : 4′ 3″, the required variation.

Moon passes the first merid. Jan. 25th at	-	3^h	7′	0″ P.M.
Longitude West, in time	*Add.*	2	3	0
Variation answering to 30° 45′	*Add.*		4	3
TIME required		5^h	14′	3″

Example 38.

Required the time at which the moon passed the meridian of Canton, in longitude 113° 2′ 45″ E. on the 20th of September, 1814. Ans. 10^h 21′ 45″ A.M.

Example 39.

Required the culmiating of the moon at Kingston, Jamaica, in longitude 76° 50′ 30″ W. on the 28th of April, 1815.

Ans. 11^h 54′ 27″ P.M.

Example 40.

At what time of the day will the moon pass the meridian of

Constantinople, East longitude 28° 55′ 15″, on the 12th of December, 1815. Ans. 7^h 44′ 35″ P.M.

Right ascension of the Stars. Art. 18.

Example 41.

What was the right ascension of *Arcturus* on the 31st of May, 1814?

Right ascen. of *Arcturus*, at the beginning of 1815,*	14^h 7′ 13″·38
Variation for 7 months, or $\frac{2{\cdot}728 \times 7}{12}$ *(Subtract.)*	1·59
Right ascension required, in siderial time -	14^h 7′ 11″·79

Example 42.

Required the right ascension of *Sirius* on the 15th of November, 1815. Ans. 6^h 37 2″·26.

Example 43.

The right ascension of *Regulus* is required on the 1st of March, 1816. Ans. 9^h 58′ 34″·3.

Example 44.

Required the right ascension of *Aldebaran* on the 30th of December, 1818. Ans. 2^h 25′ 32″·54.

Declination of the Stars. Art. 18.

Example 45.

Required the declination of α *Pegasi* on the 14th of February, 1816.

Declination at the beginning of 1815 -	14° 12′ 54″·19 N.
Annual variation, 19″·43, for one year -	+ 19·43
Variation for 1 month and 14 days -	+ 2·43
Declination required - - - - -	14° 13′ 16″·05 N.

Or 14° 13′ 16″, omitting the decimals.

* See Table XVI., at the end of this Volume.

Example 46.

What was the declination of *Fomalhaut* on the 25th of June, 1814.? Ans. 30° 35′ 34″·4S.

Example 47.

Required the declination of *Pollux* on the 10th of August, 1816. Ans. 28° 27′ 38″·43N.

Example 48.

Find the declination of *Aquilæ* on the 20th of November, 1818. Ans. 8° 24′ 0″·05N.

CHAPTER II.

Depression of the Horizon. Art. 20.

Example 49.

Required the depression of the horizon, the observer's eye being elevated 25 feet 9 inches above the surface of the sea.

Depression for 25 feet, Table I. - - -	4′ 54″
Proportional parts for 6 inches - - - -	3
Ditto - for 3 inches - - - -	1 ·5
Depression required, for 25 feet 9 inches - -	4′ 58″·5

Example 50.

Required the depression of the horizon, when the eye of the observer is elevated 16 feet 8 inches above the level of the sea.

Ans. 4′.

Example 51.

The eye of an observer is elevated 22 feet 6 inches above the level of the sea, what is the depression of his visual horizon?

Ans. 4′ 39″.

Augmentation of the Moon's Semi-diameter. Art. 28.

Example 52.

Required the moon's semi-diameter at the moment her centre passed the meridian of Greenwich, on the 30th of March, 1814, supposing her altitude to have been at that instant 52° 30′.

The moon passed the meridian of Greenwich on the day proposed at $8^h\ 3'$ P. M. and her horizontal semi-diameter at that time, calculated according to Art. 16, or Example 29, is 16'.

$$\text{Augmentation, } \textit{Table}\ \text{II.}\ \begin{cases}\text{Altitude } 45^\circ & - \quad - \quad 11''\cdot5\\ \text{Ditto } 55 & - \quad - \quad \underline{13\cdot5}\\ \quad 10^\circ & \text{Difference} \quad 2''\cdot0\end{cases}$$

Also $52^\circ\ 30' - 45^\circ = 7^\circ\ 30'$.

Consequently $11''\cdot5 + \frac{7\frac{1}{2} \times 2''}{10^\circ} = 11''\cdot5 + 1''\cdot5 = 13''$ the required augmentation answering to $52^\circ\ 30'$ of altitude. Therefore

Horizontal semi-diameter	-	16'
Augmentation - - -	-	+0 13"
Semi-diam. required -	-	16' 13"

Example 53.

Having observed the moon's altitude on the 5th of November, 1814, to be $61^\circ\ 10'\ 30''$, and finding her horizontal semi-diameter at that time to be $14'\ 50''$; what is her augmented semi-diameter on account of altitude? Ans. $15'\ 2''\cdot28$.

Example 54.

Required the moon's augmented semi-diameter when her altitude was observed to be $35^\circ\ 24'\ 45''$, and her horizontal semi-diameter was known to be $15'\ 20''$ at the time of observation.

Ans. $15'\ 29''$.

Example 55.

Suppose that at a certain place the moon's horizontal semi-diameter had been found by calculation to be $15'\ 53''$, and her altitude observed to be $56^\circ\ 28'$; it is required to ascertain her augmented semi-diameter. Ans. $16'\ 6''\cdot4$.

Refraction—Parallax of the Sun. Arts. 31 *and* 32.

Example 56.

On the 14th of May, 1814, the altitude of the sun's lower limb was observed to be $24^\circ\ 55'$, when the barometer stood at

30·324 inches, and Fahrenheit's thermometer at 60°·8; what was the refraction less parallax at the time?

The semi-diameter of the sun at the time of observation, according to the preceding rules, was 15′ 51″, and therefore the altitude of his centre was 25° 10′ 51″. The refraction less parallax, in Table V, for 25° is 1′ 55″, and the difference for the succeeding degree is 6″, the proportional part answering to 10′ 51″ is therefore very nearly 1″, which is subtractive; hence

Sun's apparent alt. 25° 10′ 51″.	Refraction, Table V.		1′ 54″
Thermometer + 60°·1 - Sun's apparent alt. 25° 10′ 51″	Table VI.	*Subtract.* - -	1
			1′ 53″
Barometer - 30in.·324 - Sun's apparent alt. 25° 10′ 51″	Table VII.	*Add.* -	2
Corrected REFRACTION - - - - - -			1′ 55″

Example 57.

The altitude of the sun's upper limb was observed to be 21° 48′, on the 7th of November, 1814; required refraction less parallax, the height of the observer's eye being 5½ feet.

Ans. 2′ 16″·6.

Example 58.

The apparent altitude of the sun's centre being 15° 27′ 30″, the barometer 29·75 inches, and Fahrenheit's thermometer 63°·72; required the refraction less parallax. Ans. 3′ 13″·6.

Example 59.

The observed altitude of the sun's lower limb on the 30th of April, 1815, being 26° 10′, the barometer 29·86 inches, and Fahrenheit's 56°·47; required the corrected refraction at the time of observation, the height of the observer's eye being 25 feet. Ans. 1′ 47″·5.

Parallax less Refraction of the Moon. Arts. 35, 36, and 37.

Example 60.

Suppose the altitude of the moon's upper limb was observed on the 15th of April, 1814, at 6^h A.M. civil time, to be 46° 39′; the latitude of the place of observation being 48° 10′ North, and the longitude 6° 30′ East; the barometer at the time was 29·32 inches, and Fahrenheit's thermometer 64°·34. Required the corrected parallax less refraction of the moon at that moment; the height of the eye being 16·4 feet above the surface of the sea?

First, 6° 30′ = 26′ of time; therefore the time of observation reduced to the first meridian is 6^h 26′ A.M. of the 15th, civil time, or 18^h 26′ of the 14th of April, astronomical time.

Moon's observed altitude - - - - -		46° 39′
Moon's semi-diameter - - -	*Subtract.* -	15 12
		46° 23′ 48″
Depression of the horizon - - - - -		— 3 58
Apparent altitude of the moon - - - -		46° 19′ 50″
Equatorial and horiz. Parallax, April 15th, at 6^h 26′ A.M.		55′ 43″
Diminution of the equat. paral. on account of latitude - -	Table III. -	6
Horizontal parallax for lat. 48° 10′ - - - -		55′ 37″
Paral.—refrac. for 46° 19′ 50″ 37′ 4″ For 37″ of horizon. paral. - + 26	Table VIII.	37′ 30″
Height of the barometer 29·32 inches Apparent altitude - 46° 19′ 50″	Table VII. -	+ 1
Height of the thermometer 64°·34 Apparent altitude - 46° 19′ 50″	Table VI. -	+ 1
Parallax—Refraction required - - - - -		37′ 32″

Example 61.

Required the parallax—Refraction of the moon when she

passed the meridian of Greenwich on the 27th of September, 1814; supposing the apparent altitude of her centre at that moment to be 53° 10′, the barometer at 29·42 inches, and Fahrenheit's thermometer 49° · 16. Ans. 32′ 55″.

Example 62.

The apparent altitude of the moon's centre having been found to be 43° 15′ 30″, and Fahrenheit's thermometer observed to stand at 72°·65, the barometer at 29·8 inches, and the horizontal parallax to be 57′ 30″: required the corrected parallax less refraction. Ans. 40′ 32″.

Example 63.

Suppose the apparent altitude of the moon's centre, after having been corrected for the dip of the horizon and semi-diameter, to be 15° 58′ at 10^h 15′ P.M. civil Greenwich time, on the 10th of October, 1815; the height of the barometer being 29·6 inches, and that of the thermometer 68°·45. Required the parallax—refraction of the moon at that time. Ans. 49′ 17″.

True Altitude of the Sun. Art. 34.

Example 64.

On the 12th of August, 1814, the altitude of the sun's lower limb was observed to be 26° 35′; the height of the thermometer was 71°·6, that of the barometer 29·12 inches, and the height of the observer's eye 21⅓ feet; required the sun's true altitude.

Sun's observed altitude - - - - -	26° 35′
Depression of the horizon answering to 21⅓ -	— 4 32″
	26° 30′ 28″
Semi-diameter of the sun, August 12th -	+ 15 49 ·5
	26° 45′ 17″·5
Refraction—Parallax to alt. 26° 46′ 17″·5, corrected for the temperature and pressure of the atmosphere - - - -	— 1 38·3
TRUE ALTITUDE of the sun - - -	26° 44′ 39″·2

Example 65.

The observed altitude of the sun's lower limb being 21° 32′, the height of the eye 28 feet above the level of the sea, and the sun's semi-diameter 15′ 58″. The true central altitude is required. Ans. 21° 40′ 31″.

Example 66.

At 10ʰ 30′ A.M. March 21st, 1814, being in East longitude 60° 21′, by account, and having observed the heights of the barometer and thermometer to be 30·12 inches and 63°·72 respectively; it is required to find the true altitude of the sun's centre, the observed altitude of his lower limb being 30° 40′ 15″, and the height of the eye, above the surface of the sea, 18 feet.

Ans. 30° 50′ 43″.

Example 67.

Required the true altitude of the sun's centre on the 26th of April, 1815, at 9ʰ 10′ P.M. civil time, in longitude 43° 20′ West; supposing the height of the barometer to be 30 inches, that of the thermometer 55°·12; the height of the observer's eye being 30¼ feet, and the observed altitude of the sun's upper limb 37° 55′. Ans. 37° 32′ 33″.

True Altitude of the Moon. Arts. 35, 36, *and* 37.

Example 68.

On the 31st of May, 1814, at midnight, in longitude 96° 25′ East, by account, suppose the observed altitude of the moon's lower limb was 32° 21′, the height of the eye 23 feet above the level of the sea; and also that the corrected parallax — refraction was found to be 37′ 32″: required the moon's true altitude at that time.

The time proposed reduced to the first meridian, or Greenwich time, is May 31st, at 5ʰ 34′ 20″ P.M. at which time the semi-diameter of the moon was 14′ 58″.

Then the moon's observed altitude - -	32°	21′	
Depression of the horizon - - - -	—	4	42′
	32	16	18
Moon's semi-diameter - - - - - -	+	14	58
Apparent altitude of the moon's centre - -	32	31	16
Corrected Parallax — Refraction - *Add.* -		37	32
True altitude required - - - - -	33°	8′	48″

Example 69.

Suppose that on the 29th of March, 1814, the altitude of the moon's upper limb was observed to be 24° 35′, at 36 minutes past 8 at night, civil time; that the height of the observer's eye was $5\frac{1}{2}$ yards, and the longitude 112° 55′ W. by account; the height of the barometer being 30·3 inches, and that of the thermometer 52°·5. Required the true central altitude of the moon at the moment of the observation. Ans. 25° 7′ .1″.

Example 70.

Let it be supposed that on the 31st of January, 1815, in longitude 63° 24 E. by account, the altitude of the moon's upper limb is found to be 44° 12′ at 10 minutes past 9, P.M. civil time, when the barometer was 30·4 inches, Fahrenheit's thermometer $3\frac{1}{2}$ degrees below the freezing point, and the height of the eye 16 feet above the surface of the water; it is required to determine the true altitude of the moon's centre.

Ans. 44° 32′ 25″.

Example 71.

Suppose that the altitude of the moon's lower limb is observed to be 38° $14'\frac{1}{2}$, on the 28th of May, 1815, at 10^h 29′ P.M. on board a vessel in longitude 101° 50′ E. according to her reckoning, at the same time that it was ascertained the barometer stood at 28·93 inches, Fahrenheit's thermometer at $79°\frac{1}{4}$, and the elevation of the eye above the surface of the sea was 18 feet. Required the true altitude of the moon's centre at the moment of taking her observed altitude. Ans. 39° 6′ 31″.

True Altitude of the Stars.

Example 72.

Suppose the observed altitude of *Arcturus* to be 53° 24′, the height of the eye $25\frac{1}{2}$ feet above the surface of the water, the barometer 30·3 inches, and the thermometer 60°·17; what is its true altitude?

Observed altitude of the star - - - -		53° 24′
Elevaton of the eye $25\frac{1}{2}$ feet. Depression -		— 4 51′
Apparent altitude - - - - - -		53° 19′ 9″
Refraction of altitude, Table V. - - - -		43″
Thermometer 60°·17 Apparent alt. 53° 19′ 9″	Table VI. Correction. -	— 0
Barometer - 30·3 inches Apparent alt. - 53° 19′ 9	Table VII. Correction. -	+ 1
Corrected Refraction - - - - - - -		44
Apparent altitude of Arcturus - - - -		53° 19′ 9
TRUE ALTITUDE required - - - - -		53° 18′ 23′

Example 73.

The observed altitude of *Aldebaran* is 45° 28′, and the height of the observer's eye $18\frac{1}{2}$ feet above the surface of the sea; required its true altitude, independently of the temperature and pressure of the atmosphere. Ans. 45° 22′ 52″.

Example 74.

Suppose the observed altitude of *Regulus* to be 34° 51′, the height of the eye 24 feet, that of the barometer 29·5 inches, and of the thermometer 35°·6; required its true altitude.

Ans. 34° 44′ 45″.

Example 75

The observed altitude of the star *Pollux* being 67° $16'\frac{1}{2}$, when corrected for the depression of the horizon, the height of the barometer 29·2 inches, and that of the thermometer 30°·34; required the true altitude of this star. Ans. 67° 16′ 5″.

Correction of the less of two Altitudes taken out of the Meridian.

This subject naturally consists of two parts; viz. the method of finding these corrections, and that of applying them: each of these shall be illustrated by examples.

Method of finding the Correction. Art. 40.

Example 76.

The altitude of the sun having been observed in North latitude 47° 25′, and found to be 23° 6′ when his declination was 13° 2′ N. Some time afterwards the sun's altitude was observed to be 36° 54′; and it was ascertained that the way made in latitude during the interval between the observations was 12′ 30″. Required the multiplier of the difference of latitude.

$$\left.\begin{array}{l}\text{Less alt. of } \odot \ 23^\circ \ \ 6' \\ \text{Latitude north } 47 \ \ 25\end{array}\right\} \text{1st term, Table XII. } 1{\cdot}46 \text{ Argum. } 1{\cdot}58$$

$$\left.\begin{array}{l}\text{Declin. North } 13^\circ \ \ 2' \\ \text{Argument - } 1{\cdot}58\end{array}\right\} \text{2nd term, Table XIII. } 0{\cdot}36.$$

2nd term $+ 2 -$ 1st term $= 2{\cdot}36 - 1{\cdot}46 = {\cdot}9$, the required multiplier.

Example 77.

Suppose that on board a vessel in latitude 56° 38′ N. the altitude of the sun was found to be 46° 54′; and that some hours afterwards his altitude was taken again, and found equal to 24° 46′; and his declination at the moment of this last observation was 18° 31′ S. The way made in latitude during the interval between the observations was 23′ towards the South; required the multiplier of the difference of latitude.

Ans. 1·68.

Example 78.

The observed altitude of the sun, in latitude 15° 20′ S. being 32° 45′, when his declination was 21° 45′ S.; and after the vessel had arrived at latitude 15° 38′ 54″, the altitude was again

observed, and found to be 52° 20′; what is the multiplier of the difference of latitude? Ans. ·711.

Example 79.

The sun's altitude being observed at two different places on the same day, the latitudes of which were 49° 57′ N. and 50° 22′ N. the less altitude being equal to 14° 44′, and corresponded to the less latitude, and his declination at the time of observation equal to 8° 56′ S. Required the multiplier of the difference of latitude. Ans. ·43.

Method of applying this Correction. Art. 41.

Example 80.

The less altitude of the sun taken at 8h A. M. on the 7th of May, 1814, was 24° 43′, and the latitude of the place of observation 38° 41′ N. Some time afterwards the sun's altitude was again taken and found to be 43° 14′, in latitude 38° 27′ N. Required the less corrected altitude, or what the less altitude would have been if observed in the place of the greater.

The declination of the sun at the time of the least observation was 16° 39′ 19″ N. the difference of latitude 14′, and the multiplier of the difference of latitude, found, as in the preceding examples, is 1·036; therefore the correction to be applied to the less altitude is 14′ × 1·036 = 14′ 30″. As the declination and latitude of the place of observation are both North, the sun passes the meridian South of the observer; and as the latitude of the place where the greater altitude was taken, ought to be greater than that where the less was observed, the meridian altitude at the former place is therefore greater than at the latter: hence,

Less altitude of the sun - - - -		24° 43′
Difference of latitude - - -	*Add.* -	14
	Sum -	24° 57′
Correction - - - - -	*Subtract* -	14 30
LESS ALTITUDE referred to the place of the greater		24° 42′ 30″

Example 81.

The sun's altitude being found equal 46° 20′, in South latitude 18° 58′; and after the ship had sailed towards the North-West until her latitude was reduced to 18° 30′, the altitude of the sun was found to be 32° 3′, and his declination at the time of the last observation equal to 5° 12′ N. Required the less corrected altitude. Ans. 32° 11′ 32″.

Example 82.

The sun's altitude and declination were found to be 25° 38′ and 20° 45′ N. respectively, in North latitude 10° 21′; and after a diminution of latitude equal to 34′, his altitude was ascertained to be 46° 24′. What is the corrected altitude of the first observation? Ans. 25° 25′ 25″.

Example 83.

Suppose that, on the 2nd of February, 1815, at 9^h 12′ A.M. civil time at Greenwich, the altitude of the sun was observed to be 8° 50′, in North latitude 6′; and that after an elapse of some hours his altitude was again ascertained to be 19° 58′, in South latitude 16′½. Required the altitude at the former place of observation when referred to the latter. Ans. 8° 21′ 38″

PRACTICAL EXAMPLES TO

CHAPTER III.

Latitude from the meridian altitude of the Sun. Art. 45.

Example 84.

March 18th, 1814, being in longitude 56° 24′ W. and having found the altitude of the sun's lower limb when he passed the meridian towards the south to be 48° 35′, and ascertained that the elevation of the eye above the surface of the sea was $26\frac{1}{4}$ feet; required the latitude of the place of observation.

By converting the longitude into time, it is found that the time of the observation reduced to the first meridian is 3^h 45′ 36″ P. M. March 18th; and, art. 16, the sun's semi-diameter taken from the Nautical Almanac and reduced to the time proposed, is 15′ 57″; hence the

Observed altitude of the sun's lower limb -		48°	35′	
Elevation of the eye $26\frac{1}{4}$ feet. Depression, Tab. I.		—	5	1
Remainder -		48	29	59
Sun's semi-diam. 18th of March, 1814, at 3^h 45′ 36″		+	15	57
Sum		48	45	56
Refraction—Parallax of the sun, Table V. -			—	45
True altitude of the sun towards the South -		48	45	11
Sun's declination - - - -	*Add.*	1	1	6
Height of the equator - - -	*Sum.*	49	46	17
Complement. LATITUDE, NORTH - -		50°	13′	43″

Example 85.

In 73° 24′ of East longitude, the altitude of the sun's upper limb was observed to be 63° 55′, when he passed the meridian northward of the observer, on the 4th of November, 1814; the

elevation of whose eye was 29 feet above the level of the sea, and the barometer and thermometer standing at 30·1 inches and 42°·73 respectively. Required the true altitude of the place of observation. Ans. 41° 40′ S.

Example 86.

Suppose, on the 8th of April, 1815, the altitude of the sun's lower limb to be found equal 39° 53′ when he passed the meridian South of the observer, in longitude 45° 22′ W. and the eye was elevated 16½ feet above the surface of the sea; the barometer standing at 28·9 inches, and thermometer at 55°·38. Required the true latitude. Ans. 56° 47′ 42″ N.

Example 87.

The sun being supposed to pass the meridian between the observer's zenith, and the North pole, on the 12th of August, 1815, and the meridian altitude of his upper limb found to be 78° 58′. The latitude of the place of observation is required, admitting the height of the eye to be 27 feet above the level of the sea, and the place of observation to be in 54° 35′ of West longitude. Ans. 3° 45′ 52′ N.

Latitude from the meridian altitude of the Moon. Art. 45.

Example 88.

On the 10th of May, 1814, being in latitude 38° 35′ N. and longitude 54° 42′ W. by account, the moon was observed to pass the meridian towards the South at 9^h 33′ P.M.; at the same time the altitude of her lower limb was ascertained to be 71° 46′, and the height of the eye 29·5 feet above the level of the sea. Required the true latitude of the place of observation, admitting the height of the barometer to have been 29·46 inches, and that of the thermometer 73°·24.

The time of the moon's passage over the meridian of the place of observation reduced to the first meridian, and taken to the nearest minute, is 13^h 19′, May 10th, astronomical time, or 1^h 19′, A.M. May 11th, civil time. The corresponding declination

of the moon is 20° 21′ N. her horizontal semi-diameter 14′ 52″, and her horizontal parallax, taken from the Nautical Almanac, 54′ 20″.

Observed altitude of the moon's lower limb -		71°	46′	
Height of the eye 29·5 feet -	Depression.	—	5	20″
	Remainder.	71	40	40
Hor. semi-diameter 14′ 52″ / Augmentation, Tab. II. 13	Moon's semi-diameter	+	15	6
Apparent altitude of the moon's centre - -		71°	55′	46″
Horizontal paral. 54′ 20″.	Paral.—Refract. Tab. VIII.	+	16	32
Barometer - 29·46 inches / Apparent alt. 71° 55′ 46″	Corrrction. Table VII.		+	0
Thermometer 73°·24 / Appar. altitude 71° 55′ 46″	Correction. Table VI.		+	1
True altitude of the moon towards the S. -		72	12	19
Declination of the moon, North - - -		20	21	
	Difference.	51	51	19
Complement. LATITUDE, NORTH - - -		38°	8′	41″

Example 89.

Being in 61° 5 E. longitude, by account, on the 13th of July, 1814, when the moon passed the meridian towards the North, at 3^h 55′ 40″ A.M. and the altitude of her lower limb was equal to 30° 10′. Required the correct latitude, independently of the temperature and pressure of the atmosphere, supposing the height of the observer's eye to have been 25 feet above the level of the sea. Ans. 45° 25′ 20″ S.

Example 90.

Suppose the observed meridian altitude of the moon's upper limb to be 74° 32′, on the 14th of April, 1815, at 7^h 27′ P.M. The moon passing the meridian North of the observer, whose eye is 20 feet above the sea; and the longitude, by account, 47° 30′ West. Required the true latitude. Ans. 7° 11′ 3″N.

Example 91.

Suppose, that on the 13th of June, 1815, at $10^h\ 19'$ P.M. the moon was observed to pass the meridian northward of the observer, who was at that time in East longitude $160°\ 45'$, by account, and the altitude of her lower limb ascertained to be $69°\ 50'$. The height of the observer's eye above the surface of the water was also found to be 28 feet, that of the barometer 30·6 inches, and of the thermometer 86°·16: it is required to find the correct latitude of the vessel at the moment of the observation. Ans. $7°\ 29'\ 34''$S.

Latitude from meridian altitudes of the Stars. Art. 45.

Example 92.

On the 14th of February, 1814, the star α *Pegasi* passed the meridian northward of the observer, and its altitude was observed at that moment to be $56°\ 36'$, and the height of the eye $21\frac{1}{3}$ feet; what was the latitude of the place of observation?

The declination of *Pegasi* at the proposed time has been found in Example 45, to be $14°\ 12'\ 37''$N. nearly.

Observed altitude of Pegasi towards the N. -	56°	36′	
Elevation of the eye $21\frac{1}{3}$ feet. Depression. -	—	4	32″
Remainder	56	31	21
Refraction. Table V. - - - - - -		—	38
True altitude of α Pegasi towards the N. -	56	30	50
Declination, North - - - - - -	14	12	37
Height of the equator - - - *Sum.*	70	43	27
Complement. LATITUDE REQUIRED. - -	19°	16′	33″ S.

Example 93.

The star *Fomalhaut* was observed to pass the meridian on the 25th of June, 1814, South of the observer, when its altitude was $68°\ 34'$, and the height of the eye above the level of the sea 26 feet. Required the latitude of the place. Ans. $9°\ 4'\ 11''$S.

Example 94.

If the star *Sirius* pass the meridian on the 1st of April, 1815, North of the observer, and its altitude be found at the instant of its passage to be 53° 49′, and the height of the eye 15 feet; what is the latitude of the place of observation?

Ans. 52° 43′ 30″S.

Example 95.

Suppose the bright star *Capella* pass the meridian on the 31st of August, 1815, at the moment its altitude is ascertained to be 64° 58′, the observer facing the North pole, and the height of his eye being 18 feet above the surface of the sea: required the latitude of the place of observation; supposing the barometer to stand at 30·3 inches, and the thermometer at 78°·7.

Ans. 21° 41′ 16″N.

Latitude from several Altitudes of the Sun taken near the Meridian. Art. 48.

Example 96.

The chronometer having been compared with the sun at half-past 9, on the morning of the 21st of March, 1814, and found to be 20′ 15″ before true time; the latitude of the place was 23° 44′ North, and its longitude 73° 10′ West. At a place which was 11′ 30″ of a degree West, and 7′ 20″ North of the former, according to the reckoning, the following observations of the sun's lower limb were taken, the height of the eye being 18 feet above the level of the sea; the barometer at 30·4 inches, and the thermometer at 76°·5: required the latitude of this last place of observation.

The time, by the chronometer, at which the sun would have passed the meridian in the situation where its gain was ascertained would have been 12^h 20′ 15″; but as the place of which the latitude is required is 11′ 30″ of a degree, or 46″ of time, West of the former, the passage of the sun over the meridian of this latter place will be at 12^h 21′ 1″. The time of this passage

reduced to the first meridian is, therefore, March 21st, at $4^h\ 53'\ 26''$, P.M. The declination of the sun at that moment is therefore $11'\ 9''$N.

Time of passing the Meridian $12^h\ 21'\ 1''$.

Time of obs. by the watch.	Altitudes.	Intervals.	Squares of inter. or Multipliers.
$12^h\ 16'\ 50''$	$65°\ 1'\ 15''$	$4'\ 11''$	$17'{\cdot}5$
18 14	65 46 8	2 47	7·75
20 40	66 19 33	0 21	0·1
21 54	66 23 36	0 53	0·8
23 16	66 42 44	2 15	5·05
24 10	67 4 33	3 9	9·9
Divide by 6)	397 17 49	Sum	$46'{\cdot}05$
Mean altitude	$66°\ 12'\ 58''$	The sixth. Multiplier	7·68

Change in altitude during the last minute before the sun passes the meridian. Table IX.	4·6
	30·72
	4·608
Number to be added to the mean altitude. Product.	$35'{\cdot}328$

Mean observed altitude		$66°\ 12'\ 58''$
Elevation of the eye 18 feet	Depression	— 4 9
	Remainder	66 8 49
Semi-diameter of the ☉		+ 16 4
		66 24 53
Refraction — Parallax. Table V.		— 23
True mean altitude of the ☉		66 24 30
Correction to be added		35
Meridian altitude, towards the S.		66 25 5
Declination N.		11 9
Altitude of the equator.	*Difference.*	66 13 56
Complement. LATITUDE required N.		$22°\ 46'\ 4''$

Example 97.

On the 18th of September, 1814, suppose the following series

of observations to have been made on the sun's lower limb; and the time indicated by a watch that was 53′ 44″ before true time at the first meridian. The height of the observer's eye being 22 feet above the level of the sea, the latitude 36° 41′N. and the longitude 25° 32′E. by account: required the correct latitude of the place of observation.

Times of observation		Observed altitudes
11ʰ 7′ 0″	- -	55° 19′ 2″
8 48	- -	19 39
10 12	- -	19 55
12 30	- -	20 2
12 55	- -	20 5
13 38	- -	20 11
Mean altitude		55° 19′ 41″

Answer. 36° 30′ 40″N.

Example 98.

On the 27th of April, 1815, suppose the following altitudes of the sun's upper limb to be observed, in latitude 12° 14′S. and longitude 103° 52′E. according to the ship's reckoning. The height of the eye being 24 feet; the barometer standing at 30·6 inches; Fahrenheit's thermometer at 80°·1; and the chronometer by which the respective times of the observations were noted, known to be 1ʰ 26′ behind true time at the place of observation. Required the correct latitude.

Times of observation.		Observed altitud
10ʰ 31′ 25″	- -	75° 9′ 9
33 15	- -	9 56
34 58	- -	10 2
35 27	- -	10 16
Mean altitude	-	75° 9′ 51″

Answer. 12° 50′ 46″ S.

Example 99.

Suppose that, on the evening of the 8th of July, 1815, on board a vessel at anchor near one of the Society Islands, and in

South latitude 18° 10′, and West longitude 150° 20′, according to her reckoning; the subsequent observations were made on the sun's lower limb, for the purpose of ascertaining the latitude of the vessel with more correctness. The watch by which the time of each observation was indicated being found to agree with true time at the place of observation, the barometer at 29·9 inches, the thermometer 82°·4, and the height of the eye 16½ feet. What is the true latitude?

Times of observation.		Observed altitudes
11h 54′ 52″	- -	49° 30′ 50″
57 32	- -	31 44
59 7	- -	31 58
12 1 16	- -	32 4
3 54	- -	32 40
5 18	- -	33 15
Mean altitude		49° 32′ 5″

Answer 17° 45′ 21″ South.

Latitude from two altitudes of the Sun taken out of the meridian and the interval of time between the observations. *Art.* 62, *&c.*

Example 100.

Suppose that on the 12th of April, 1814, on board a vessel in N. latitude 33° 30′, and W. longitude 67° 30′, by account, the altitude of the sun's lower limb was found to be 28° 36′, when a good chronometer, regulated to true time at the first meridian, indicated 7h 27′ 12″. When the same chronometer gave 11h 51′, the altitude of the sun's lower limb was again taken, and found to be 63° 49′. The elevation of the eye in each of these observations was 16⅓ feet above the surface of the sea; and during the interval between them the vessel sailed towards the South-East until her change in latitude was 15′ 20″ of a degree, and that of her longitude 18′ 24″. Required the correct latitude of the place where the greater altitude was observed.

Time by the watch.

At the place of the less altitude - - -	7h 27′ 12″
Less altitude taken to the West of the greater -	— 1 13·6
Corrected time of the less altitude - -	7h 25′ 58″·4
Time at the place of the greater altitude -	11 51
Interval in time - - - - - -	4h 25′ 1″·6
Interval in degrees - - - - - -	66° 15′ 24″
Half interval - - - - - - -	33 7 42

Reduced time, Declination and Latitude.

Estimated time of the less altitude - -	7h 27′ 12″
Longitude West, in time - - *add*	4 30
Time reduced to the first meridian - -	11 57 12
Estimated time of the greater altitude -	11h 51′ 0″
Longitude West, in time, 4h 30′ — 1′ 14″, *add*	4 28 46
Time at the first meridian - - -	16h 19′ 46″
Declination. { Less altitude - - -	8° 11′ 9″N.
Declination. { Greater altitude - - -	8 15 9 N.
Mean declination - - - - - -	8 13 9 N.
Mean decl. taken from 90°. *Polar distance.* -	81 46 51
Estimated latitude of the less altitude -	33 30 0
Difference of latitude - - - *Subtract.*	15 20
Estimated latitude of the greater altitude -	33° 14′ 40″

Less Altitude.

Observed altitude of the sun - - -	28° 36′ 0″
Elevation of the eye 16½ feet - Depression	— 3 58
	28 32 2
Sun's semi-diameter - - - - - -	+ 15 50·6
	28 47 52·6
Refraction—Parallax - - - - - -	— 1 37·6
True altitude of the sun - - - - -	28 46 15
Diff. of latitude of the places of observation -	+ 15 20
Sum	29° 1′ 35″

Sum	29° 1′ 35″
Product of the diff. of latitude by the multiplier found by Tables XII. and XIII, according to Arts. 40 and 41, or 15′ 20″ × ·84 - -	— 12 52
Less altitude corrected for the place of the greater	28° 48′ 43″

Greater Altitude.

Observed altitude of the sun	- - -		63° 49′ 0″
Elevation of the eye $16\frac{1}{3}$ feet.	-	Depression	— 3 58
			63 45 2
Sun's semi-diameter	- - - - -		+ 15 50 ·6
			64 0 52 ·6
Refraction — Parallax	- - - - - -		— 24
True altitude of the sun	- - - - -		64° 0 28″·6

Azimuths.

The azimuth corresponding to the multiplier found above, viz. ·84, taken from Table XIV, is 81°, which is the greater azimuth, or that answering to the less altitude. The multiplier agreeing with the greater altitude is found in the same manner as that for the less, and is ·05, and the corresponding azimuth 18°: which is less than a fourth of the greater: hence,

Half interval	33° 7′ 42″	sin. 9·7376030	cotang. 10·1853551
Polar distance	81 46 51	sin. 9·9955020	comp. cos. 0·8447679
Half dist. of sun's places	32° 44′ 38″	sin. 9·7331050	tang. 11·0301230
Double. Distance 65 29 16		*First angle at the sun*	84° 40′ 22″

Second angle at the Sun.

Greatest alt. of the sun	64°	0′	29″		
Least corrected ditto	28	48	43	comp. cos.	0·0573937
Dist. of the sun's places	65	29	16	comp. sin.	0·0410193
Sum	158°	18′	28″		
Half sum	79	9	14	cos.	9·2745544
Half sum — greater alt.	15	8	45	sin.	9·4171007
		Sum	- - -		18·7900681
		Half sum	-	sin.	9·3950340
		Half 2nd angle at sun			14° 22′ 44″

Angle of variation.

Half the 1st angle at the sun - - -		42° 20′ 11″
Half the 2nd ditto - - - -	*Subtract.*	14 22 44
Half the *angle of variation* - -	Difference	27° 57′ 27″

Calculation of Latitude.

Half the angle of variation	27°	57′	27″	cos.	9·9461052
Sun's polar distance -	81	46	51	½ sin.	4·9977580
Less corrected alt. of sun -	28	48	43	½ cos.	4·9713031
Polar distance — less altitude	52°	58′	8″		
Difference from 90° - -	37	1	52		
Half difference - -	18	30	56	comp. cos.	0·0230829
Auxiliary angle	63°	9′	37″	sin.	9·9382492
				cos.	9·6968589
Cos. Auxil. angle — comp. cos. half difference. Cos.					9·6737760
Half sum of latitude + 90° - - - -					61° 50′ 52″
Double — 90 { Latitude of the place of the greater altitude - - }					33° 43′ 44″

Example 101.

On the 22nd of January, 1814, being in north latitude 13° 22′ ½, and 35° of west longitude, by account, the altitude of

the sun's upper limb was taken at 1h 6' by a well regulated watch, and found to be 57° 6'; 1h 10' afterwards, the altitude of his lower limb was found to be 30° 37'. The height of the observer's eye in both these observations was 24 feet above the level of the sea; and the difference in latitude and longitude during the interval was 12½ miles towards the South, and 15 towards the East. Required the true latitude of the place where the greater altitude was observed. Ans. 13° 28' N.

Example 102.

Suppose that on the 15th of February, 1815, in South latitude 29° 42', according to the ship's reckoning, at a time when the sun's declination was 12° 55' South, the altitude of his lower limb was found to be 32° 16'; and four hours and a quarter afterwards the altitude of the same limb was again observed, and found to be 73°. The course of the vessel, during the interval, was South-East by East, at the rate of seven knots an hour, and the height of the eye at each observation 19 feet. Required the corrected latitude of the place where the last observation was made? Ans. 29° 12' 18" S.

Example 103.

Suppose, that on the 21st of October, 1815, on board a vessel in North latitude 20° 34', and East longitude 115° 42', by account, the altitude of the sun's lower limb to be 17° 35', at 8h 10' A.M. by a watch that had been ascertained to be 38' 15" before true time, on the preceding evening, in East longitude 115° 17'. At 12h 30' by the same watch, suppose the observed altitude of the sun's lower limb was again taken and found to be 58° 48'; the height of the eye in both these observations being 18 feet above the level of the sea; and the ship sailing at the rate of 6 knots an hour, on a North-East course; the height of the mercury in the barometer at the time of the last observation being 29·3 inches, and the thermometer at 76°·46. Required the corrected latitude of the place of the last observation. Ans. 20° 42' 18" N.

PRACTICAL EXAMPLES TO

CHAPTER IV.

Calculation of the horary angle from Altitudes of the Sun.
Art. 75.

Example 104.

SUPPOSE that on the 24th of May, 1814, about $7^h\frac{1}{4}$, A.M. civil time, in North latitude 43° 15′, and East longitude 23° 30′, the following observations of the sun's lower limb was made, when the elevation of the eye was 18 feet above the level of the sea. it is required to determine the time at the place of observation.

Times by the watch.			Observed altitudes.
7^h 14′ 38″	-	-	29° 2′ 15″
15 21	-	-	3 16
16 0	-	-	4 10
17 25	-	-	5 55
18 37	-	-	7 37
19 37	-	-	9 5
Sum - 101′ 36″	-	Sum -	32′ 18″
Mean time 7^h 16′ 29″		Mean altitude	29° 5′ 23″

The mean astronomical time reduced to the first meridian is the 23rd at 17^h 42′ 29″; and the true altitude of the sun's centre obtained by correcting the mean altitude, 29° 5′ 23″, for depression of the horizon, semi-diameter, refraction and parallax is 29° 15′ 28″. The corresponding declination is 20° 51′ North; and as the latitude is North also, the distance of the sun from the elevated pole is 69° 9′. Hence

True altitude of the sun	20° 15′ 28″				
Latitude	-	43 15 0	-	comp. cos.	0·1376454
Polar distance	-	69 9 0	-	comp. sin.	0·0203654
Sum	-	141 29 28			
½ Sum	-	70 49 44	-	cos.	9·5163916
½ Sum — altitude	-	44 34 16	-	sin.	9·8218707
			Sum	-	19·4962750
			½ Sum.	sin.	9.7481375
		Half the horary angle			34° 3′ 4″
		Multiplying by	-	-	8
		Horary angle in time			4ʰ 32 24″·5
The observation being made in the morning, subtract the time from 12 hours				-	7ʰ 27′ 35″·5
Time by the watch	-	-	-	-	7 16 29
Watch too slow	-	-	-	-	0ʰ 11′ 6″·5

Example 105.

Being in latitude 40° 2 North, longitude 85° 50′ West, on the 5th of August, 1814, at 6ʰ 30′ A.M. by the watch, the observed altitude of the sun's lower limb was, from the mean of six observations, found to be 15° 49′ 44′, and the height of the observer's eye 16 feet above the level of the sea. Required the difference between the time by the watch and true time.

Ans. 3′ 7″ very nearly, too fast.

Example 106.

Suppose that on the 15th of November, 1814, at 3ʰ 0′ 5″ P.M the mean observed altitude of the sun's upper limb was found, from a series of observations, to be 16° 4′ 22″, corresponding to the above time′; the latitude of the vessel being 51° 42 North, and the longitude 33° 1′ West, by account, and the height of the eye 14 feet above the surface of the water; what was the error of the watch?

Ans. 23′ 38′ too slow.

Example 107.

Suppose that in South latitude 33° 56, and East longitude 18° 12′, by account, several altitudes of the sun's upper limb were observed, and from ascertaining the time of each by a

good chronometer, the mean time is found to be 40 minutes past 3, P.M. on the 27th of March, 1815, and the mean corresponding altitude 25° 20′ 19″. Required the time at the place of observation, and the error of the chronometer; the height of the eye being 17½ feeet above the level of the sea; the barometer 30½ inches, and Fahrenheit's thermometer 77°·82.

Ans. { True time - 3^h 23′ 34″.
Chronometer too fast 16 26.

Horary angle from the Altitude of a Star. *Art.* 77.

Example 108.

At 30 minutes past 4, P.M. by the watch, on the 14th of December, 1814, being on board a vessel in latitude 37° 46′ North and longitude 21° 15′ East, by account, the mean altitude of *Arcturus*, when East of the meridian, was found, from a series of observations, to be 34° 7′ 12″; at the same time that the height of the observer's eye was 15 feet above the level of the sea. Required the true time at the place, and the error of the watch.

The time of the observation reduced to the meridian is 3^h 5′. The declination of *Arcturus* was at that time 20° 9′ 32″ North: and, as the latitude and declination are both of the same name, the polar distance of the star was 69° 50′ 28″; and its right ascension, in time, 14^h 7′ 11″. The sun's right ascension at the same moment is 17^h 25′ 27″. Hence

The apparent altitude of *Arcturus*	-	34°	7′	12″
Elevation of the eye 15 feet. Depression		—	3	48
		34	3	24
Refraction - - - - -		—	1	24
True altitude of *Arcturus* - -		34°	2′	0″

True altitude of the star	34°	2′	0″		
Latitude of the place -	37	46	0	comp. cos.	0·1020918
Polar distance of the sar	69	50	28	comp. sin.	0·0274529
Sum - - -	141°	38′	28″		
Half Sum - -	70	49	14	- cos.	9·5165661
Half Sum — Altitude	36	47	14	- sin.	9·7773172
				Sum - - -	19·4234280
				Half Sum - - sin.	9·7117140
				Half the horary angle -	30° 59′ 24″
				Multiplying by - -	8

Star East.	Subtract {	Horary angle in time	6h 7′ 55″
		Right ascension of the star	14 7 11
		Right ascen. of the meridian	9 59 16
		Add 12 hours - -	12
			21 59 16
		Sun's right ascension - —	17 25 27
		True time at the place -	4 33 49
		Time by the watch -	4 30
		Watch too slow -	0h 3′ 49″

Example 109.

Being at sea on the 7th of July, 1814, and in S. latitude 29° 12′, and E. longitude 55° 15′; according to the ship's reckoning, at 21 minutes past three o'clock, A.M. by a watch that was about 20′ too slow, when the apparent altitude of *Antares*, West of the meridian, was ascertained to be 7° 50′ 58″, and the height of the observer's eye was 21 feet above the surface of the water. It is required to calculate the true time at the place of observation, and to ascertain the error of the watch.

Ans. { True time 3h 40′ 3″ A.M.
Watch too slow 0 19 3

Example 110.

Suppose it should be ascertained, from a series of six observations, taken on the evening of the 1st of February, 1815, that

the mean altitude of *Pollux*, when East of the meridian, was equal to 36° 45′ 32″, and the mean corresponding time equal to 6^h 12′ 40″, P.M. by a good seconds watch. The latitude being 53° 24′ North, and longitude 25° 18′ West, by account, and the height of the eye 18 feet; also the height of the barometer equal to 30·2 inches, and Fahrenheit's thermometer 28°·4. Required the difference between the true time at the place of observation and that indicated by the watch.

Ans. Watch too fast, 0^h 0′ 37″.

Example 111.

Suppose, that on the 20th of September, 1815, in South latitude 40°, and East longitude 110°, when the chronometer on board the vessel, which was about 1^h 53′ before true time at the place of observation, was 9^h 13′ P.M. the mean altitude of *Fomalhaut*, East of the meridian, was, from a series of six observations, ascertained to be 45° 11′ 12″; the height of the mercury in the barometer 30·2 inches, Fahrenheit's thermometer standing at 72°, and the height of the observer's eye being 19 feet above the level of the sea. Required the true time at the place of observation, and the error of the chronometer.

Ans.	True time at the place of observ.	7^h	21′	4″
	Chronometer too fast -	1	51	56.

CALCULATION OF ALTITUDES.

True Altitudes of the Sun. *Arts.* 78, 80.

Example 112.

Required the true altitude of the sun on the 14th of July, 1814, at 3^h 42′ 20″ P.M. in latitude 5° 55′ 45″ S. and longitude 152° 3′ E.

As the time for which the altitude is required is after noon, the time expressed in degrees will give the horary angle; and the other elementary quantities of the calculation will be easily found by the preceding rules: hence,

The horary angle	-	55°	36′	30″
The given latitude	-	5	55	45
Sun's declination	-	21	44	48
Polar distance	-	111°	44	48

Half the horary angle -	27°	48′	15″	-	cos.	9·9467210
Polar distance	111	44	48	-	½ sin.	4·9839684
Latitude - -	5	55	45	-	½ cos.	4·9988352
Polar dist. — latitude -	105	49	3			
Difference from 90° -	15	49	3			
Half difference from 90° -	7	54	16	comp.	cos.	0·0041458
Auxiliary angle				-	sin.	9·9336704
Ditto - - -				-	cos.	9·7101529
(Cos. auxil. angle — comp. cos. ½ diff. 90°) -					cos.	9.7060071
½ (90° + altitude)				-		59° 27′ 30″
(*Double* — 90°). TRUE ALTITUDE of the sun				-		28 55.

Example 113.

Required the sun's altitude on the 27th of October, 1814, at 9^h 10′ 15″ A.M. in North latitude 43° 24′, and West longitude 58° 33′ 21″. Ans. 12° 5′ 38″.

Example 114.

What will be the true altitude of the sun at 10 minutes past four, P.M. on the 12th of May, 1815, in South latitude 23° 30′, and East longitude 12° 48′? Ans. 19° 3′ 40″.

Example 115.

Required the sun's true altitude on the 4th of August, 1815, at 7^h 50′ 50″, A.M. by a watch that had been ascertained to be 27′½ too slow. The latitude of the place being 15° 40′ North, and the longitude 72° 0′ 45″ West. Ans. 37° 0′ 56″.

True Altitudes of the Moon. Arts. 79, 80.

Example 116.

Being in North latitude 26° 47′, and East longitude 36° 45 on the 4th of May, 1814, at 58 minutes past ten in the evening,

by a watch that was 13′ 5″ before true time. Required the true altitude of the moon's centre at that moment.

Time by the watch - -		10^h	58′	
Watch too fast - *Subtract* -			13	5″
True time at the place of the req. alt.		10	44	55
Longitude, East, in time -	—	2	27	0
Time reduced to the first meridian -		8^h	17′	55″

Time at the first place of the required alt.		10^h	44′	55″
Sun's right ascension - -	*Add.*	2	44	49
Right ascension of the meridian -		13	29	44
Ditto in degrees - - - -		202	26	0
Right ascension of the moon - -		227	11	0
Horary angle of the moon, to the East -		24	45	0
Declination of the moon S. - -		12	51	0
Distance from the elevated pole -		102	51	0

Half the horary angle -	12° 23′	-	cos.	9·9897766
Polar distance -	102 51	-	½ sin.	4·9944924
Latitude - -	26 47	-	½ cos.	4·9753569
Polar dist. — latitude -	76 4			
Difference from 90° -	13 56			
Half diff. from 90° -	6 58		comp. cos.	0·0032183
	Auxiliary angle -		sin.	9·9628442
			cos.	9·5983679
(Cos. auxil. angle — comp. cos. ½ diff.)		-	cos.	9·5951496
	½ (90 + altitude)	-	-	66° 49′
(*Double* — 90°). TRUE ALTITUDE of the moon			-	43 38′.

Example 117.

Required the true altitude of the moon's centre, on the 8th of September, 1814, at 4^h 30′ 35″, A.M. by the watch, in latitude 11° 6′ South, and longitude 72° 13′ 21″ East; the watch by which the time was ascertained having been found, from altitudes of the sun taken on the preceding evening, to be 21′ 14″ too slow. Ans. 49° 11′ 46″.

Example 118.

It is required to calculate the true altitude of the moon's centre on the 12th of April, 1815, at 5h 50′ 10″, P.M. in latitude 37° 44′ S. and longitude 47° 27′ W. Ans. 18° 48′ 52″.

Example 119.

Suppose that on the 24th of August, 1815, the true altitude of the moon's centre was required; but that the horizon could not then be sufficiently distinguished to admit of its being ascertained by observation. Also, that at the moment for which the altitude is required, a good watch, which, at 20 minutes past nine on the preceding morning, had been found to be 11′ 31″½ too fast, and to have regularly gained 3″¾ per day since the last time it had been regulated, indicated 11h 35′ 42″ P.M. The latitude of the place of the required altitude being 18° 41′ 10″ N. and the longitude 63° 16′ 20″ W. and the height of the eye 16 feet. The true altitude is required from calculation.

Ans. 48° 12′.

True Altitudes of the Stars. Arts. 79, 80.

Example 120.

On the 26th of February, 1814, at 40 minutes past three in the afternoon, being in North latitude 47° 23′, and West longitude 32° 48′ 14″, the chronometer on board was found to be 12′ 29″ too fast with respect to true time. The vessel then pursued a NW. by W. course, at the rate of six knots an hour for the space of three hours and ten minutes. Required the true altitude of the star *Pollux* at the termination of this course.

Length of course 19 miles	Change in latitude -	10′ 36″ W.
	Ditto in longitude -	15 48 W.
Latitude of the vessel at the first observation -		47° 23′ 0″ N.
	Change in latitude - *Add.*	10 36
Latitude of the place of the required altitude -		47 33 36
Longitude at the place of the first observation		32° 48′ 14″ W.
	Change - *Add.*	15 48
Longitude of the place of the required altitude		33° 4′ 2″

Time by the watch at the first observation	-	3h	40′	3″
Duration of course	*Add.*	3	10	0
Watch too fast	*Subtract.*		12	29
True time at the place of the required altitude		6	37	31
Longitude West, in time	*Add.*	2	12	16
True time reduced to the first meridian	-	8h	49′	47″

Time at the place of the required altitude	-	6h	37′	31″
Sun's right oscension	*Add.*	20	59	44
		27	37	15
	Subtract.	24		
Right ascension of the meridian	-	3h	37′	15″
In degrees	-	47°	29′	0″
Right ascension of the star *Pollux*	-	107	15	40
Horary angle. The star to the East of the meridian		59	46	40
Declination of Pollux	N.	28	27	58
Distance from the elevated pole	-	61	32	2

Half the horary angle	29°	53′	20″	cos.	9·9380158
Polar distance	61	32	2	½ sin.	4·9720189
Latitude	47	33	36	½ cos.	4·9145932
Polar dist. — latitude	13	58	26		
Difference from 90°	76	1	34		
Half diff. from 90°	38	0	47	comp. cos.	0·1035468
Auxiliary angle.				sin.	9·9281747
				cos.	9·7248392
(Cos. auxil. angle — comp. cos. ½ difference)				cos.	9·6212924
½ (90° + altitude)					65° 17′ 5″
(*Double* — 90°). TRUE ALTITUDE of *Pollux*					40 34 10

Example 121.

Required the altitude of the star *Fomalhaut*, on the 21st of September, 1814, at midnight, in South latitude 8° 49′, and East longitude 87° 21′ 15″. Ans. 56° 30′.

Example 122.

Calculate the altitude of *Aldebaran*, in South latitude 25° 23′ and West longitude 30° 10′ 12″, on the 25th of January, 1815, at 20 minutes past ten at night. Ans. 35° 24′.

Example 123.

Find the altitude of *Antares* on the 20th of August, 1815, at 32 minutes past eleven at night, in latitude 25° 31′ South, and longitude 36° 31′ East. Ans. 21° 12′.

PRACTICAL EXAMPLES TO

CHAPTER V.

Regulation of Marine Chronometers. *Art.* 88.

Example 124.

Being in South latitude 30° 25′, and East longitude 78° 27′, on the 5th of February, 1814, the mean altitude of the sun was found, from a series of six observations, to be 34° 20′, and the mean corresponding time by the chronometer, 7^h 58′ 5″ A.M. On the 11th of the same month, a second series of observations was made, from which the sun's mean altitude was ascertained to be 29° 31′ 48″, and its corresponding time by the same chronometer 7^h 20″ A.M. The latitude of the place of the second observation was 32° 48′ South, and its longitude 83° 37′ East. Whether had the chronometer gained or lost, with respect to mean time, during the interval between the observations, and what was its rate?

True time of the first observation, found by the rules in art. 75 - - - - -	8^h 3′ 5″
Equation of time February 5 - - - - -	+ 14 22
Mean time of the first observation - -	8 17 27
Time by the chronometer at ditto - - -	7 58 5
Chronometer too slow Feb. 5th at 7^h 58′ 5″ A.M.	0^h 19′ 22″
True time of the 2nd observation, Feb. 11th -	7^h 45′ 3″
Difference of longitude in time - - - -	— 20 40
True time of the second observation reduced to the place of the first - - - - -	7 24 23
Equation of time February 11th - - - -	+ 14 36
Mean time of the second observation - -	7^h 38′ 59″

Mean time of the 2nd observation - - -	$7^h\ 38'\ 59''$
Time by the chronometer - - - - -	7 20 0
Chronometer too slow, February 11th, at $7^h\ 20'$ A.M.	$18'\ 59''$
Ditto February 5th at $7^h\ 58'\ 5''$, A.M. - -	19 22
Gain in 6 days - - - - - - -	$23''$
Divide by 6. GAIN in 24^h, OR RATE - - -	$3''\frac{5}{6}$

Example 125.

On the 30th of August, 1814, the true altitude of the sun's centre, found from a series of observations, was 11° 52′, and the corresponding time by the chronometer $5^h\ 27'\ 16''$ P.M.; the latitude of the place of observation being 48° 35′ North, and the longitude 62° 43′ West. On the 7th of the following month, at 5^h 30° 31″ P.M. the altitude was again found equal to 8° 54′ 25″, the latitude and longitude being the same as before. Required the gain or loss of the chronometer with respect to mean time, and its rate during the interval between the observations.

Ans. { Gain during the interval 48″·8.
Daily rate increasing 6·1.

Example 126.

Suppose, on the 1st of May, 1815, at $5^h\ 2'$ P.M. by the chronometer, the mean altitude of the sun's lower limb, found from a series of 6 observations, to be 20° 26′ 35″; the latitude of the place of observation being 53° 21′ North, and longitude 3° 57′ 20″ East. Again, on the 12th of May, at the same place, the mean altitude being 14° 11′ 53″, and the corresponding time, by the same chronometer, 6^h P.M. The height of the eye, above the surface of the sea in both cases being 18 feet; required the variation of the chronometer from mean time at each observation, and its daily rate during the interval between the observations.

Ans. { At the first obs. chronom. too fast 3′ 45″·8
At the second obs. chronom. do. 3 31 ·6
Daily rate during the interval, *loss* 0 1 ·17.

Example 127.

On the 3rd of October, 1815, at $8^h\ 35'$ A.M. suppose the mean

altitude of the sun's centre to be 38° 53′, in South latitude 5° 59′, and East longitude 105° 32′. And again on the 15th of the same month, at 10^h 20′ A.M. suppose his mean altitude from a series of observations to be 65° 4′ 40″, the latitude of the place of observation being 9° 10′ South, and longitude 104° 54′ E. Required the rate of the chronometer by which the time was observed, the height of the eye at each observation being 20 feet above the level of the sea.

Ans. Daily gain 6″·9 nearly.

Longitude by Marine Chronometers. Art. 93.

Example 128.

On the 20th of February, 1814, that is 9 days after the chronometer had been ascertained to be 18′ 59″ too slow, and to gain $3''\frac{5}{6}$ in 24 hours, (See example 124,) six altitudes of the sun's upper limb were taken, and the mean altitude found to be 38° 50′, and the mean corresponding time of the observation, by the chronometer, 9^h 7′ 10″ A.M. the longitude of the place where the chronometer was regulated was 83° 37′ East, and the height of the observer's eye 21 feet above the level of the sea. The latitude of the place where the mean altitude of the sun was taken was 34° 10′ South, and the longitude, by account, 75° 21 E. Required the true longitude of the vessel at the place of the last observation.

Latitude, by account - - - - - - -	34°	10′	0
Longitude by ditto - - - - - - -	75	21	0
Mean observed altitude of the sun's upper limb	39	11	46
Elevation of the eye 21 feet. Depression -		— 4	30
Sun's apparent altitude - - - - -	39	7	16
Sun's semi-diameter - - - - - - -		— 16	12
	38	51	4
Refraction — Parallax - - - - - - -		— 1	4
True altitude of the sun - - - - -	38	50	0

Time by the chronometer corresponding to the mean altitude, February 20th - -	9^h	$7'$	$10''$
Chronometer too slow when regulated, February 11th at 7^h $20'$ A.M. - - - - - -		+ 18	59
	9	26	9
Gain in nine days, from the rate $3''\frac{5}{6}$ - - -		−	34
	9	25	35
Equation of time - - - - - - -	−	14	8
True time at the place of regulation - -	9	11	27
Longitude East 83° 37′ in time - - - -	− 5	34	28
Time at the first meridian, A.M.	3^h	$36'$	$59''$

Declination of ☉, South - - - - -	11°	9′	7″
Distance from the elevated pole - - - -	78	50	53

True altitude ☉. -	38°	50′	0″		
Latitude - - -	34	10	0	comp. cos.	0·0822806
Polar distance - -	78	50	53	comp. sin.	0·0082790
Sum	161	50	53		
½ Sum	75	55	26	- cos.	9·3859840
Half sum — altitude -	37	5	26	- sin.	9·7803724
				sum	19·2569160
				½ Sum sin.	9·6284580

Half the horary angle - - - - - -	25°	9′	18″
Multiplying by - - -			8
Horary angle in time - - - - - -	3^h	$21'$	$14''$
Comp. to 12^h. Time at the vessel - - -	8	38	46
Time at the place where the chronometer was regulated - - - - -	9	11	27
Vessel to the West of the place of regulation -	0^h	$32'$	$41''$
In degrees -	8°	10′	15″
Longitude of the place where the chronometer was regulated - - - - - -	83	37	
LONGITUDE required - - - - - - E.	75°	26′	45

Example 129.

Suppose, that on the 10th of July, 1814, the true time was found to be $2^h\ 52'\ 12''$ P.M. at the moment that a well regulated chronometer, which was known to be $12'\ 27''$ before true time at the first meridian, gave $5^h\ 50'\ 10''$. Required the longitude of the place. Ans. $41°\ 7'\ 45''$ West.

Example 130.

On the 15th of May, 1815, suppose the true time, found by an altitude of the sun, to be $7^h\ 56'\ 54''$, A. M. civil time, at the moment that a well regulated chronometer, which was $13'\tfrac{1}{2}$ behind mean time at the first meridian, gave $6^h\ 8'\ 30''$. Required the longitude of the place of observation.

Ans. $23°\ 1'\ 45''$ East.

Example 131.

Suppose, on the 21st of August, 1815, at $6^h\ 25'$, P.M. true time, obtained by an altitude of the sun, that a chronometer, which was then with mean time at the first meridian, indicated $10^h\ 39'\ 33''$, and was found to gain $3''\tfrac{1}{2}$ daily. Also, on the 2nd of September following, in latitude $34°\ 28'$ North, and longitude $75°\ 45'$ West. Suppose the altitude of the sun's lower limb to be $21°\ 50'\ 20''$ when the same chronometer gave $9^h\ 37'\ 20''$ P.M. the height of the eye above the surface of the sea being 16 feet. Required the true longitude of the vessel at this last station.

Ans. $75°\ 29'$ West.

Correction of Longitude found by Chronometers. Art. 97.

Example 132.

On the 22nd of March, 1814, at 3^h P.M. from observations of the sun's altitude, the chronometer on board a vessel was found to be $37'\ 15''\cdot4$ too fast, in longitude $57°\ 24'$ West; and to have a daily rate of increase equal to $2''\cdot1$. On the 2nd of May following, at ten minutes past five in the afternoon, the same chronometer was found to be too slow with respect to

mean time at the place of observation, by $1^h\ 18'\ 22''\cdot5$; and the daily rate of increase was then $3''\frac{1}{2}$. Required the correction to be applied to the longitude of this last place of observation, as found from the first daily variation of the chronometer, and also the corrections of the longitude found by the same means on the 30th of March, and the 12th and 21st of April.

Daily variation of the chronometer at the 1st obser. -		$2''\cdot1$
Ditto at the second observation - - -		$3\cdot6$
	Sum	$5\cdot7$
Mean variation - - - - -	$\frac{1}{2}$ Sum	$+\ 2\cdot85$

Chronometer too fast at the first observation -	$37'\ 15''\cdot4$
Accumulated gain from March 22nd to May 2nd 41 days $2^h\ 10'$ at $2''\cdot1$ per day - -	$+\ \ 1\ \ 26\cdot3$
Chronometer too slow at the 2nd observation	$+\ 1^h\ 18\ \ 22\cdot5$
Diff. of long. in time, between the two places of observ. according to the first variation, $2''\cdot1$	$1^h\ 57'\ \ 4''\cdot2$
Difference of longitude in degrees - - - -	$29°\ 16'\ \ 3''$
Difference of longitude calculated in the same manner with the mean variation, $2''\cdot85$ -	$29\ \ 23\ \ 45$
Since, by the nature of the question, the vessel was evidently sailing eastward, the correction of the diff. of long. on the 2nd of May, calculated with the first daily variation, $2''\cdot1$, is	*diff.* $7'\ 42''$

The place arrived at is therefore East of that which is found by means of the first diurnal variation.

Correction of longitude $7'\ 42''$, or $462''$ - -	log.	$2\cdot6646420$
Multiple, from Table XI, answering to 41 days $2^h\ 10'$, between March 22nd, and May 2nd -	865, comp. log.	$7\cdot0629839$
Constant logarithm	Sum	$-\ 1\cdot7276259$
From the 22nd to 30th March, 8 days, Multiple from Table XI. - -	36 log.	$1\cdot5563025$
	Sum	$1\cdot2839284$

Sum . 8339284

Correction for the longitude found March 30th - 9″·23

By adding the logarithm of the multiple answering to 21 days, from March 22nd to April 12th, Table XI. the correction - - - } = 2′ 3″·4

Also for the 21st of April the correction is found in the same manner, and is - - - } = 4′ 8″·4

Example 133.

On the 12th of August, 1814, the watch was found to lose 5″·3 in 24 hours, and to correspond to mean time at 8^h 23′ A.M. in longitude 30° 14′ 22″ West. On the 1st of September following, the same watch was found to lose 3″ per day, and to be 1^h 14′ 36″ behind mean time at the place of observation. Required the corrections to be applied to the longitude found by this watch on the 22nd and 27th of August, on account of the variation in its rate.

Ans. { On the 22nd 16″·76. On the 27th 36 ·57.

Example 134.

Having regulated the chronometer to mean time at Plymouth harbour, previously to sailing for the West Indies, on the 12th of November, 1814, at 9^h 42′ A.M. when it corresponded with mean time at that port, and the variation for the last 24 hours was nothing: but on the 27th of the same month, at a quarter before four P.M, the same chronometer was found to be 53′ 24″·8 before mean time at the place of observation, and to be gaining at the rate of 4″·6 per day. Required the correction to be applied to the longitude of this last place of observation found from the chronometer, as regulated at Plymouth harbour, and also that which must be applied to the longitude found by the same means on the 20th of the month; the place of departure being in longitude 4° 8′ 10″ West.

Ans. { On the 20th 1 38″. On the 27th 5 57.

Example 135.

Suppose that on the 6th of June, 1815, before sailing from

the Cape of Good Hope, in longitude 18° 24′ East, the watch was found to gain 2″·4 per day, with respect to mean time, but after 25 days sailing it was ascertained to lose 3″·7 per day. Required the corrections which it is necessary to apply to the longitudes found by this watch on the 15th, 20th, and 28th of the same month.

Ans. On the 15th 0′ 23″.
On the 20th 0 58.
On the 28th 2 7.

PRACTICAL EXAMPLES TO

CHAPTER VI.

Longitude from distances of the Moon from the Sun and Stars.

Method of finding the Altitude of the heavenly bodies, the distance of which has been observed. Art. 104.

Example 136.

On the morning of the 15th of March, 1814, before taking the distance between the sun and moon, the mean altitude of the sun's lower limb, from a series of observations, was found to be 12° 40′ 3″, and the corresponding time 7ʰ 10′ 14″. The altitude of the moon's upper limb, when West of the meridian, was likewise ascertained to be 37° 59′ 31″, and the time, by the watch, answering to this observation 7ʰ 11′ 2″. The time answering to the mean observed distance between the nearest limbs of these bodies was 7ʰ 13′ 9″. After this, the altitude of the sun's lower limb was again found to be 13° 35′ 39″, and the corresponding time 7ʰ 14′ 53″. Also the altitude of the moon's upper limb, and the corresponding time of the observation were again found to be 37° 25′ 56″, and 7ʰ 16′ 5″. Required the true altitudes of the centres of these bodies at the instant of the mean observed distance, the height of the observer's eye being 21½ feet above the level of the sea.

		Times.		*Altitudes of the Sun.*
1st observation	-	7ʰ 10′ 14″	- -	12° 40′ 3″
2nd observation	-	7 14 53	- -	13 35 39
1st interval	- -	0ʰ 4′ 39″	Difference	0° 55′ 36″

Time of the first observation - - - -	7^h 10′ 14″
Time of observing the mean distance - - -	7^h 13 . 9
2nd interval - - - - - - -	0^h 2′ 55″

Then

1st inter. 4′ 39″ : 2nd inter. 2′ 55″ : : 1st change in alt. 55′ 36″ : 2nd change in altitude. By logarithms,

1st interval - -	4′ 39″ = 279″	comp. log.	7·5543958
2nd interval - -	2 55 = 175	- log.	2·2430380
1st change in altitude	55 36 = 3336	- log.	3·5232260
2nd change in altitude	34 52 = 2092	- log.	3·3206598

Observed altitude of the sun - - - -	12° 40′ 3″
2nd change in altitude. *Sun ascends.* - *Add*	34 52
Altitude of the sun at the time of the observed dist.	13° 14′ 55″
Sun's semi-diameter - - - - -	+ 16 6
Sum -	13 31 1
Height of the eye 21½ feet - *Depression*	− 4 33
Refraction — Parallax - - - - -	− 3 23
True altitude of the SUN - - -	13° 23′ 5″

	Times.		*Altitudes of the Moon.*
1st observation -	7^h 11′ 2″	- -	37°. 59′ 31″
2nd observation -	7 16 5	- -	37 25 56
1st interval - -	0^h 5′ 3″	- *Difference*	0° 33′ 35″

Time of the first observed altitude - -	7^h 11′ 2″
Time of observing the mean distance - -	7 13 9
2nd interval - - - - - -	0^h 2′ 7″

Then

1st inter. 5′ 3″ : 2nd inter. 2′ 7″ : : 1st change in alt. 33′ 35″ : 2nd change in altitude. By logarithms,

1st interval - -	5′ 3″ = 303″	comp. log.	7·5185574
2nd interval - -	2 7 = 127	- log.	2·1038037
1st change in altitude	33 35 = 2015	- log.	3·3042751
2nd change in altitude	14 5 = 845	- log.	2·9266362

1st observed altitude of the moon - - -	37°	59′	31″
2nd change in altitude. *Moon descends.* Subtract		14	5
Altitude of the moon at the time of the obs. distance	37°	45′	26″
Semi-diameter of the moon - - - -	—	14	58
☾ Difference	37	30	28
Height of the eye 21½ feet - - *Depression*	—	4	33
Parallax — Refraction of moon - - -	+	41	52
True altitude of the Moon - - - -	38°	7′	47″

Example 137.

Suppose the distances and altitudes of the sun and moon were observed to be as follow: it is required to find the true altitudes at the time corresponding to the mean distance; supposing the observations to have been made on the morning of the 19th of July, 1814, and the height of the eye 15 feet above the level of the sea.

Times.	Observed alt. ☉'s low. limb.		Times.	Observed alt. ☾'s lower limb.
8ʰ 2′ 30″	- 39° 42′	-	8ʰ 2′ 0″	- 20° 46′
7 0	- 40 20	-	6 10	- 21 20
Diff. 0ʰ 4′ 30″	Diff. 0° 38′		Diff. 0ʰ 4′ 10″	Diff. 0° 34′

	Time.		Obs dist. Sun and Moon's nearest limbs.
	8ʰ 3′ 20″	-	- 40° 0′ 0″
	4 20	-	- 0 30
	5 50	-	- 1 30
Mean	8ʰ 4′ 30″	-	Mean 40° 0 40″

Ans. True altitude. { Sun's centre 40° 9′ 50″.
Moon's centre 22 12 25.

Example 138.

Let it be supposed that the distance between the nearest limbs of the sun and moon was observed at 6ʰ 10′ 21″ P.M. when they were both West of the meridian, and that the altitude of the sun's lower limb was found to be 18° 12′ 16″ at 6ʰ 5′ 14″; and that of the moon's lower limb 31° 11′ 24″, at 6ʰ 7′ 12″. Also

that the altitude of the same limb of the sun at 6h [illegible]′ 34″, was 17° [illegible]′ 38″; and likewise that the altitude of the moon's lower limb was 30° 17′ 15″, at 6h 12′. Required the true altitude of the centre of each of these bodies at the time of observing the distance between them; the height of the observer's eye being 18 feet above the surface of the sea; and the observations made on the 5th of April, 1815.

Ans. { Altitude sun's centre 18° 6′ 51″.
Ditto Moon's centre 31 31 57.

Example 139.

Suppose the distance between the farthest limb of the moon and the star Antares to have been observed, at 10h 2′ 41″ P.M. on the 12th of October, 1815, when the former was East, and the latter West of the meridian; and that 2′ 3″ before this observation, the altitude of the moon's lower limb was ascertained to be 43° 12′ 14″, and that of the star at 10h 1′ 3″, was 57° 4′. Also, that at 10h 3′ 56″, the altitude of the moon's lower limb was again found to be 44° 3′, and that of Antares 56° 25′ 7″. Required the respective altitudes of these bodies at the moment of observing the distance between them, the height of the eye being 19 feet.

Ans. { True altitude of moon's centre 44° 32′ 16″.
True altitude of Antares - - 56 37 27.

Calculation of the true distance, the time at the first Meridian, and the Longitude. Art. 109, *&c.*

Example 140.

Suppose that on the 8th of August, 1814, about 6h 30′ A.M. in North latitude 51° 30′, and East longitude, by account, 24°, the mean observed distance between the nearest limbs of the sun and moon was 99° 8′ 20″, as ascertained by a series of six observations. The observed altitude of the sun's upper limb being 8° 27′ 39″, and that of the moon's lower limb 54° 27′ 4″. The height of the observer's eye being 16 feet; that of the barometer 30·3 inches, and of Fahrenheit's thermometer 67°·7. Required the true longitude of the vessel at the time of the observation.

Elements of the Calculation.

Latitude North	51°	30′	0″
Time by account	6^h	30′	0″
Longitude in time E.	1	36	0
Time at the 1st merid.	4	54	0
Sun's semi-diameter		15′	48″
Moon's semi-diameter		15	47
Aug. of moon's semi-dia.			13
Moon's semi-dia. corrected		16	0
Moon's equatorial paral.		57	50
Diminution of parallax		—	7
Moon's parallax corrected		57	43
Sun's observed altitude	8°	27′	39″
Depression of horizon	—	3	55
Diff.	8	23	44
Sun's semi-diameter	—	15	48
Sun's apparent altitude	8	7	56
Refract — Par. 5′ 52″; Therm. 67° — 9; Baromet. 30·3 in. + 5	—	5	48
Sun's true altitude	8°	2′	8″

Moon's observed altitude	54°	27′	4″
Depression of the horizon	—	3	55
Diff.	54	23	9
Moon's semi-diameter	+	16	0
Moon's apparent altitude	54	39	9
Parallax — Refraction 32′ 40″; Thermometer 67° + 1; Barometer 30·3 in. — 1	+	32	40
Moon's true altitude	55	11	49
Sun's Declin. 7th August at noon	16	33	50
Sun's Declin. 8th August ditto	16	17	1
Difference in 24 hours		16	49
Proportional diff. for 17 hours		12	10
Declin. at the time of observ. N.	16	11	40
Diff. from 90°. Polar distance	73	48	20
Observed distance ☉ ☾	99°	8′	20″
Sun's semi-diameter		15	48
Moon's ditto		16	0
Apparent distance ☉ ☾	99°	40′	8″

Calculation of the true distance.

Apparent distance ☉ ☽	99°	40′	8″		
Sun's appar. altitude	8	7	56	comp. cos.	0·00[illegible]36
Moon's ditto	54	39	9	comp. cos.	0·237[illegible]
Sum	162	27	13		
½ Sum	81	13	36	cos.	9·1837853
Appar. dist. — ½ Sum	18	26	32	cos	9·9771029
Sun's true altitude	8	2	8	cos.	9·9957148
Moon's ditto	55	11	49	cos.	9·7564515
Sum	63	13	57	Sum	39·1550992
				½ Sum	19·5775496 — 9·6473244 sin. aux. angle.
½ Sum	31	36	58	cos.	9·9302252 — 26° 21′ 30″ aux. angle.
Auxiliary angle				cos.	9·9523248
Sum — 10				sin.	9·8825500
Half distance					49° 44′
Double. TRUE DISTANCE *required*					99 28

Calculation of the time at the first Meridian.

Dist. in table { at 3^h A.M.	100° 2[illegible]' 6″	1st diff 1° 33′ 45″	= 5625″	comp. log. 6·2498775
at 6^h	[illegible]8 53 21	1st interval 3^h	= 10800	log. 4·0334238
True distance -	99 28 0	2nd diff 59′ 6″	= 3546	log. 3·5497387
	2nd interval - -	1^h 53′ [illegible]″	= 6808	Sum [illegible]8330400

Time of the first distance in the Table		3^h
Second Interval - - - -	(*Add.*)	1 53′ [illegible]
TRUE TIME at the first Meridian -	Sum	4^h 53 28″

Calculation of the time at the place of observation, and of the Longitude.

Sun's true altitude -	8° 2′ 8″		
Latitude of the place -	51 30 0	- comp. cos.	0·2058504
Polar distance -	73 48 20	- comp. sin.	0·0175837
Sum	133 20 28		
Half Sum	66 40 14	- - cos.	9·5982997
Half Sum — Sun's true alt.	58 38 6	- - sin	9·9313912
		Sum	19·7531250
		Half Sum - sin.	9·8765625
		Half horary angle	48° 49′
		Multiplying by -	
TRUE TIME at the place of observation		- - -	6^h 30′ 3[illegible]″
Time at the first meridian		- - -	4 53 28
Longitude in time		- - -	1^h [illegible]′ 4″
LONGITUDE *required*, in degrees		-	24° 16′ E.

Example 141.

Suppose that on the 25th of April, 1814, about 4^h P.M. in latitude 19° 59′ South, and longitude 60° East by account, the following observations of the sun and moon were taken. Required the true longitude of the vessel at the time of the mean observation.

Observed distance ☉ ☾'s nearest limbs.	Observed altitude ☉'s lower limb.	Observed altitude ☾'s upper limb.
69° 43′ 0″	24° 1[illegible]	45° 51′
44 10	24 0	52
44 40	23 36	53
45 30	23 0	55
46 0	22 42	56
46 30	22 [illegible]	57

Ans. 60° 14′ 4[illegible] East from Greenwich, or the first meridian.

Example 142.

On the 18th of October, 18[illegible], being in North latitude 34° 47′, and West longitude 37° 30′, by account, it was ascertained by a series of observations at 4^h 12′ P.M. that the distance between the nearest limbs of the sun and moon was 61° 55′ 8″. The observed altitude of the sun's upper limb at the time of taking the distance, found by a simultaneous observation, was 16° 2′ 48″; and that of the moon's lower limb, found by the same means, 32° 51′ 45″. The height of the thermometer was 63°·8; that of the barometer 29·2 inches, and the eye 18 feet above the level of the sea. Required, the true longitude of the vessel at the time answering to the mean observed distance. Ans. 37° 51′ W.

Example 143.

On the 4th of May, 18[illegible], at 6^h [illegible] A.M. civil time, in latitude 48° 10′ North, and longitude 8° [illegible] East, by account, suppose the distance between the nearest limbs of the sun and moon to be 59° 36′, the altitude of the sun's lower limb being at the time of observing the distance, 16° 31′ 35″, and that of the upper limb of the moon 25° 2′ 52″. Also the heights of the barometer and thermometer such as to counterbalance each other's influence, and the elevation of the eye 21 feet. Required the true longitude of the place of observation.

Ans. 7° 47′ 15″ E.

Longitude from the distance between the Moon and a Star. *Art.* 120.

Example 144.

On the 2nd of March, 1814, at $10^h\ 1'\ 44''$ P.M. by a watch that had been found from an observation of the sun, taken a few hours before, to be $17'\ 34''$ too fast, being in South latitude $15°\ 21'$, and West longitude of $34'\ 42''$, by account, the distance between the nearest limb of the moon and the star *Regulus* was found to be $29°\ 20'$. Required the true longitude of the place of observation.

Elements of the calculation of the Altitudes.

Latitude -	15°	21′	0″ S.	Right ascens. of ☾	119°	58′	15″
Right ascen. of *	149	36	58	Declination of ☾	20	20	17 N.
Declination of *	12	52	21 N.	Polar dist. of ☾	110	20	17
Polar dist. of *	102	52	21				

Altitude of the Star.

Time by the watch -	10^h	1′	44″
Watch too fast -	—	17	34
True time at the place -	9	44	10
Sun's right ascension -	22	51	7
Right ascen. of the merid.	8^h	35′	17″
In degrees -	128°	49′	15″
Right ascen. of the star	149	36	58
Horary angle of the star } Star to the East - }	20	47	43

Half horary angle -	10°	24′	- cos.	9·9928059
Polar distance of the star {	102	52	- sin.	4·9944780
Latitude - - {	15	21	- - ½ cos.	4·9921121
Polar dist. — latitude -	87	31		
Difference from 90° -	2	29		
Half diff. from 90° -	1	15	comp. cos.	0·0001034
Sum. Auxiliary angle			sin.	9·9794994

Sum. Auxiliary angle.	-	sin.	9·9794994
Auxiliary angle.	-	cos.	9·4778396
(Cos. auxil. angle — comp. cos. ½ difference).	-	cos.	9·4772362
½ (90° + altitude)	-		72° 28′ 15″
(*Double* — 90°). TRUE ALTITUDE of the star	-		54 56 30

Moon's Altitude.

Right ascension of meridian in degrees		128° 49′ 15″
Right ascension of the moon	- -	119 58 15
Horary angle of the moon } Moon to the West	-	8° 51′ 0″

Half the horary angle	- 4° 25′ - -	cos.	9·9987084
Polar distance of ☾	110 20 -	½ sin.	4·9860289
Latitude - -	15 21 -	½ cos.	4·9921121
Polar dist. — latitude	94 59		
Difference from 90°	4 59		
Half diff. from 90° -	2 30 -	comp. cos.	0·0004135
Sum. Auxiliary angle	-	sin.	9·9772629
Auxiliary angle	-	cos.	9·4988245
(Cos. aux. angle — comp. cos. ½ difference.)		cos.	9·4984110
½ (90° + altitude) -	-		71° 22′ 5″
(*Double* — 90°). TRUE ALTITUDE of the ☾	-		52 44 10.

Elements for calculating the true distance.

True time at the place	9h 44′ 10″	True altitude of star	54° 56′ 30″
Longitude W. in time	+ 38 19	Refraction - -	+ 40
True time at first meridian	10h 22′ [illegible]″	Apparent altitude of star	54 57 10
Moon's semidiameter	16′ 12	Moon's true altitude -	52 44 10
Augmentation of semid.	+ 14	Approximate par.—ref.	— 35 11
Sum	16 26	Approximate altitude	52 8 59
Moon's horiz. parallax	59 21	Parallax — Refraction	- 35 42
Diminution of parallax	— 1	Moon's apparent alt.	52° 8′ 28″
Parallax corrected	- 59 20		

Observed distance moon and star	29° 20′ 0″
Moon's semi-diameter	16 [illegible]
Moon's apparent distance	29 36 20

Calculation of the true distance.

Appar. dist. moon and star	29°	36	20		
Apparent altitude *	34	57	10	comp. cos.	0·24[illegible]
Apparent altitude ☾	52	[illegible]	28	comp. cos.	0·21[illegible]
Sum	136	42	4		
½ Sum	68	21	2	cos.	9·5569402
Half sum — distance	38	44	36	cos.	9·8920708
True altitude of *	54	56	30	cos.	9·7592221
True altitude of ☾	52	44	10	cos.	9·7[illegible]1047
Sum	107	40	40	Sum	39·4532665
				½ sum	19·7266332 } 9·9557386 sin.
½ sum	53	50	20	cos.	9·7708946 } aux. ang. 64° 34′ 40″.
Auxiliary angle				cos.	9·6320793
Sum — 10				sin.	9·4[illegible]9739
Half the true distance					14° 39′
Double. TRUE DISTANCE					29 18.

Longitude.

Dist. in Tab. { 2nd at 9^h, 30° 8′ 58″ 1st diff. 1° 46′ 44″ = 6404″ comp. log. 6·1935487
at 12, 28 22 14 1st interval 3^h = 10800 log. 4·0334238

True distance 29 18 0 2nd diff. 50′ 58″ = 3058 log 3·4854375

2nd int. 1^h [illegible] 57″ = 5157 Sum 3·7124100

True time at the first meridian	-	10^h 25′ 57″	
True time at the place of observ.	-	9 44 10	
Longitude in time		Diff. 0 41 47	
Required LONGITUDE, in degrees		10 26′ 45″ West.	

Example 145.

On the 26th of September, at 10 minutes before 8, P.M. 1814, by a chronometer that had been ascertained on the 20th of the same month to be 24′ 39″ too slow, and to lose 3½″ per day, the distance between the moon's nearest limb and the star

Antares was found to be 85° 18′ 52″. The latitude of the place of observation was 24° 10′ North, and the longitude 33° 45′ West, by account. Required the true longitude of the place of observation. Ans. 33° 30′ 45″ W.

Example 146.

Suppose that on the 29th of April, 1815, at 4^h 54′ A.M. civil time, in latitude 44° 38′ N. and longitude 46° 30′ W. by account, the distance between the farthest limb of the moon and the star *α Pegasi* was found equal to 68° 37′ 10″. What was the true longitude of the place of observation?

Ans. 46° 19′ W.

Example 147.

Suppose, that at 10^h 8′ 48″ P.M. on the 14th of August, 1815, in latitude 8° 24′ South, and longitude 62° 12′ East, by account, the observed distance between the nearest limb of the moon, and the star *Fomalhaut*, is found to be 69° 52′ 48″; the apparent altitude of the moon's centre being 55° 2′ 36″, and that of the star 41° 32′ 40″. Required the true longitude of the place of observation. Ans. 62° 36′ E.

PRACTICAL EXAMPLES TO

CHAPTER VII.

Azimuth and Declination of the Needle. Art. 132.

Example 148.

REQUIRED the sun's true azimuth and the declination of the magnetic needle, about 6h A.M. on the 7th of June, 1814, in latitude 26° 30′ North, and longitude 29° 15′ East, when the observed altitude of the sun's lower limb was 24° 11′, the height of the observer's eye 16 feet above the level of the sea, and the azimuth observed with the compass 51° 36′ from the North.

Polar distance - -	67° 19′			
Sun's true altitude -	24 21	-	comp. cos.	0·0398912
Latitude - - -	26 30	-	comp. cos.	0·0482081
Sum	118 10			
Half Sum	59 5	-	cos.	9·7107863
Polar distance — ½ Sum	10 14	-	cos.	9·9930359
	Sum	-	-	19·7919215
	Half Sum	-	cos.	9·8959607
	Half azimuth	-		38° 5′
Double. Azimuth from N. toward E.		-	-	76 10
Azimuth taken with the compass N.		-	-	51 36
DECLINATION of the magnetic needle		-	-	24° 34′ NE.

Example 149.

At the island of St. Helena, the sun's central altitude was

found to be 30° 23′ in the forenoon, his declination at the same time was 22° 58′ South, and the sun's azimuth, as observed with the compass, 49° 53′. Required the true azimuth and the declination of the needle.

Ans. { Azimuth 72° 21′ from the South. Declination 22 28 NW.

Example 150.

Suppose that on the 10th of April, 1815, in North latitude 42° 29′, and West longitude 50°, the sun's morning azimuth was observed to be South 54° 24′ E.; and in the evening when the sun was at the same altitude, his azimuth was 89° 46′ W. The elapsed time between the observations being 6h 20′. Required the variation of the compass. Ans. 7° 24′ Easterly.

Example 151.

Suppose that in the afternoon of the 12th of October, 1815, the altitude of the sun's lower limb was found to be 7° 52′ about 10 minutes before five, in latitude 43° 22′ North, and longitude 30° 16′ W. The height of the eye being equal to 18 feet, and the azimuth, observed with the compass, 85° 32′ NW. Required the sun's true azimuth and the declination of the needle.

Ans. { Sun's azim. from the N. - 108° 58′ W. Declination of the needle N. 23 32 W.

Amplitude and Declination of the Needle. Art. 136.

Example 152.

On the 22nd of June, 1814, about 7h 45′ in the evening, in latitude 45° 32′ North, and longitude 64° 4′ West, the amplitude of the sun was observed to be 4° 44′ from the West towards the North. Required the true amplitude and the declination of the magnetic needle.

The declination of the sun at the time of the observation was 23° 27½′; and therefore

Declination of the sun N. -	23° 27½′		sin.	9·5999725
Latitude - - - -	45 32		comp. cos.	0·1545955
		Sum -	sin.	9·7545680

	Sum - sin.	9·7545680
Amplitude of the sun W.	- - -	34° 38′ N.
The observed azimuth W.	- - -	43 44 N.
DECLINATION of the magnetic needle	- -	9° 6 NW.

Example 153.

Required the moon's true amplitude at rising in North latitude 35° 8′, when her declination is 13° North.

Ans. E. 15° 58′ N.

Example 154.

Required the sun's true amplitude at his setting in latitude 42° 30′ South, his declination being 20° South.

Ans. W. 27° 38′ N.

Example 155.

In North latitude 30° 48′, the sun rises about 7^h in the morning on the shortest day, at which time suppose his amplitude was observed with the compass to be E. 49° 52′ S. Required the true amplitude and the declination of the needle in 1815, and in longitude 37° 45′ West.

Ans. { Amplitude at rising E. 27° 37′ S.
Declination of the needle 22 15 NW.

Astronomical Bearings of objects. Art. 142.

Example 156.

On the 18th of October, 1814, being in North latitude 34° 47′, and West longitude 37° 30′, by account, about 4^h 12′ P.M. the altitude of the sun's lower limb was observed to be 16° 3′, that of the summit of a distant mountain, 2° 58′, and the distance between the summit and the nearest limb of the sun 65° 33′. These observations were simultaneous, the height of the eye 18 feet, and the mountain on the right hand of the sun's vertical. Required its bearing at the time of the observation.

Elements of the Calculation.

Latitude, North -	34° 47′	Observed alt. of sun -	16° 12′
Longitude, West -	37 30	Depression of the horizon	— 4
In time - -	2h 30′		16 8
Estimated time at the place	4 12	Sun's semi-diameter - -	+ 16
Time at the first meridian -	6h 42′	Sun's apparent altitude -	16 24
Sun's declination	9° 35′ S.	Refraction—Parallax	— 3
Polar distance -	99 35	Sun's true altitude -	16° 21
Observed dist. of the mount. from the sun's nearest limb	65 53′	Obs. altitude of the mount.	2° 58′
Sun's semidiameter - -	+ 16	Depression of the horizon	— 4
Appar. dist. of sun's centre	66° 19′	Apparent alt. mountain -	2° 54′

Calculation of the Sun's Azimuth.

Polar distance -	99° 35′			
Sun's true altitude -	16 21	-	comp. cos.	0·0179279
Latitude - -	34 47	-	comp. cos.	0·0854901
Sum - - -	150 43			
Half sum - -	75 21	-	- cos.	9·4029724
Polar dist. — ½ Sum -	24 14	- -	cos.	9·9599384
	Sum		-	19·4663288
	Half Sum		cos.	9·7331644
	Half azimuthal angle			57° 15′
Double. The sun's azimuth from the North			-	114 30 W.

Calculation of the Difference of the Azimuths.

Apparent distance of the sun	66° 19′		
Apparent altitude of the sun	16 24	comp. cos.	0·0180392
Apparent alt. of the mountain	2 54	comp. cos.	0·0005565
Sum -	85 37		
Half Sum	42 48 -	cos.	9·8655362
Apparent dist. — ½ Sum -	23 22 -	cos.	9·9628358
Sum - -			19·8469677

	Sum		19·8469677
	Half Sum	cos.	9·9234838
	Half diff. of azimuths		33° 2′
Mount. to the *right* of sun's vertical.	Diff. of azim.		66 4
Sun's azimuth from North			114 30 W.
Subtract. THE MOUNTAIN bears from the N.			48 26 W.

Example 157.

Suppose, that on the 8th of August, 1814, at 6ʰ 30′ A.M. in latitude 51°. 30′ N. and longitude 24° E. the altitude of the sun's upper limb was 17° 18′ 30″, and that of the top of an object, on the right of the sun's vertical, 3° 6′; at the same time that the distance between the nearest limb of the sun and the summit of the mountain was 81° 43′, and the height of the observer's eye 15 feet. Required the bearing of the mountain.

Ans. Mountain bears from the S. 12° E.

Example 158.

On the 4th of May, 1815, at 6ʰ 35′ A.M. civil time, and in latitude 48° 10′ North, and longitude 8° 7′ East, suppose the altitude of the sun's lower limb to be 16° 52′, that of the summit of a mountain on the left of the sun's vertical 2° 57′, and the observed distance between this summit and the sun's nearest limb 71° 14′. Required the bearing of the mountain, the height of the observer's eye being 18 feet.

Ans. Bearing of the mountain from the N. 13° 48′ E.

Example 159.

On the 8th of September, 1815, at 5ʰ 10′ P.M. near the coast of Mexico, latitude 19° 12′ North, longitude 96° 4′ West, suppose the altitude of the sun's lower limb to be 18° 32′ 22″, the distance of his nearest limb from the summit of one of the Mexican mountains 50° 25′, and the observed altitude of the latter 5° 18′ 30″. Required the true bearing of the mountain, it being on the left of the sun's vertical circle, and the height of the observer's eye 21 feet above the surface of the sea.

Ans. Bearing of the mountain from the S. 40° 38 W

Bearings from Altitudes taken near noon. *Arts.* 145 *and* 146.

Example 160.

Approaching the entrance of Boston harbour, on the coast of North America, the latitude of the vessel being 42° 22′ N. and the longitude 70° 56′ W., by account, on the 1st of March, 1814, when the time by the watch was 9h 20′ A.M. civil time, an object on the coast was observed to be on the right of the sun's vertical circle. It had also been found, a short time before, that the watch was too slow with respect to true time, by 1h 23′ 10″. Now, suppose the observed elevation of the sun's lower limb, that of the top of the object, and the distance between the object and the nearest limb of the sun, found by simultaneous observations,* to be 37° 56′, 3° 12′, and 96° 22′ respectively. Required the bearing of the object, the height of the observer's eye being 16 feet above the surface of the sea.

Elements of the Calculation.

Time by the watch -	9h 20′ 0″	Sun's observed altitude	37° 56′ 0″
Watch too slow -	1 23 10	Depression of the horiz.	— 3 55
True time of the bearing	10 43 10		37 52 5
Subtract from -	12	Sun's semi-diameter -	+ 16 10
Horary angle -	1h 16 50	Sun's apparent alt.	38 8 15
Horary angle in degrees	19° 12′ 30″	Observed dist. sun and obj.	96 22 0
Latitude North -	42 22	Sun's semi-diameter	+ 16 10
Complement latitude -	47 38	App. dist. sun's centre	96 38 10
Longitude West -	70 56		
Longitude in time -	4h 43′ 44″	Obs. alt. of the object	3° 12′ 0″
Time of the bearing -	10 43 10	Depression of the horizon	— 3 55
Time at 1st meridian, P.M.	3h 26′ 54″	Objects appar. altitude	3° [illegible] 5″
Sun's declination, South -	7° 33′ 48″		
Sun's dist. from the elev. pole	97 33 48		

Calculation of the Sun's Azimuth.

Sun's polar dist.	97° 38′ 48″				
Complement lat.	47 38 0				
Sum -	145 16 48				
Difference	50 0 48				
Half Sum -	72 38 24	C. sin.	0·0202473	C. cos.	0·5252383
Half difference -	25 0 24	sin.	9·6260566	cos.	9·9572521
Horary angle -	19 15				
Half horary angle	9 37 30″	cot.	10·7706097	cot.	10·7706097
Sum -		tang.	10·4169136	tang.	11·2531001
1st angle -			69° 3′	2nd angle	86° 48′
				1st angle	69 3
Sun passes the meridian towards depressed pole. *Add* Azimuth of the sun from the North -					155° 51′

Calculation of the difference of the Azimuths.

Sun's apparent distance -	96° 28′			
Sun's apparent altitude -	38 8	-	comp. cos.	0·1042594
Object's apparent altitude -	3 8	-	comp. cos.	0·0006497
Sum -	137 51			
Half Sum	68 57	-	cos.	9·5553152
Appar. distance — half sum	27 41	-	cos.	9·9472027
		Sum	-	19·6074270
		½ Sum	- cos.	9·8037135
Half difference of the azimuths - - - -				50° 29′
Double. Difference of the azimuths - -				100 58
Object to the right of the sun's vertical circle, *Add* the sun's azimuth from the North -				155 51 E.
		Sum	-	256 49
		Subtract	-	180
Bearing of the object from the South - -				76° 49′ W.

Example 161.

Suppose, that near the Cape of Good Hope, in latitude 33° 58′ South, and longitude 18° 25′ East, on the 1st of May, 1814, at 11h 15′ A.M. civil time, by a watch that had been ascertained on the previous evening to be too slow by 1h 3′ 1″, it was found that the altitude of the sun's lower limb was 33° 30′, and the distance of his nearest limb from the summit of a mountain, on the left of his vertical circle, 58° 22′, the observed altitude of which was 4° 21′. The place where the watch had been found to be too slow was 21′ 30″ of a degree to the West of that where the other observations were made. Required the bearing of the mountain, the height of the eye being 22 feet above the level of the sea.

Ans. 48° 21′ from the N. towards the W.

Example 162.

Suppose, that on the 28th of December, 1814, at 10 minutes after one o'clock in the afternoon, the Peak of Teneriffe was seen on the left of the sun's vertical circle, and the observed distance between its summit and the nearest limb of the sun was found to be 72° 34′; the altitude of the former being 2° 7′, and of the lower limb of the latter 34° 46′, at the same time. The latitude of the vessel was 29° 5′ N. and the longitude 16° 32′ West, by account, and the height of the eye 21 feet above the surface of the sea. Required the bearing of the Peak at the time of the observation.

Ans. From the South. 53° 9′ E.

Example 163.

Suppose, that on the 13th of February, 1815, soon after entering the Eastern extremity of the Straits of Magellan, and in latitude 52° 40′ S. and longitude 71° 4′ W. by account, it was required to ascertain the bearing of a remarkable object, which then appeared on the left of the sun's vertical circle; and that, for this purpose, the altitudes of the sun's upper limb, and the top of the object, with the distance between the nearest

limb of the sun and the object, taken at the same instant by three observers, were respectively 50° 52′, 3° 36′ and 84° 24. The time of the observation was 28′ P.M. by a chronometer, that 9 days before had been ascertained to be 58′ 27″ too fast, with respect to true time, and to gain at the rate of 2″·9 daily; and the height of the eye 21 feet above the level of the sea. Required the bearing of the object.

Ans. From the S. 76° 2′W.

ADDITION.

On clearing the Distance.

THE following concise and easy method of clearing the apparent distance between the moon and the sun or a star from the effects of parallax and refraction, has been extracted from a paper communicated by the learned Dr. Brinkley, Professor of Astronomy in the University of Dublin, to the Royal Irish Academy, and published in the 11th volume of their transactions. The facility which this method affords in solving this troublesome problem, strongly recommends it to mariners; and in order to render it independent of all other tables, than those given in this volume, a table of natural versed sines, corresponding to every minute of the quadrant, has been added. Whenever the versed sine of an arc greater than 90° is required, it is easily found by taking the versed sine of its supplemental arc from 2.

Thus, in the first of the following examples, where the arc is 103° 29′, the supplement of which is 76° 31′; we have 2 − vers. 76° 31′ = 2 − ·766838 = 1·233162.

PRACTICAL RULE.

1. Find, by help of a table, the parallax answering to the moon's altitude, and to the complement of the altitude. The latter will be the argument of table 1. Or

Compute them by adding the proportional log. of the horizontal parallax to the arithmetical complement of the log. cos.

and log. sin. of alt., the sums will be the prop. logs. of the respective parallaxes.

2. Moon's par. — moon's refrac. = corr. of alt. Take diff. of (corr. of altitude + star's or sun's refraction + moon's alt.) and star's altitude (or sun's alt. + par.) This diff. is the diff. of true altitudes. Find also diff. of apparent altitudes.

3. When the sun is observed, add together the numbers in tables 1, 2, 4, and 5. When a star is observed, add the numbers in tables 1, 2, 3, and 5, log. of this sum (its index being always 3 + number of figures), + log. (vers. sin. observed distance — vers. sin. diff. observed altitudes) rejecting 10 from the index = log. of a number to be subtracted from the above diff. of versed sines.

4. The remainder + vers. sin. diff. of true altitudes = vers. sin. of true distance.

Observation. No distinction of cases occur. No proportional parts but such as are taken out by inspection. The versed sines may be considered as whole numbers, the radius being (1,000,000). In taking out the versed sines of the observed distance, the seconds may be reserved and added to the conclusion. Also in finding the log. of (vers. sin. observed distance — vers. sin. diff. obs. alt.) the two last figures may be considered as cyphers.

For those conversant in contracted decimal multiplication, the third precept may stand as follows.

3. When the sun is observed, take the sum of the numbers in table 1, 2, 4, and 5. When a star, the sum of the numbers in table 1, 2, 3, and 5. Find also the excess of the versed sine of the observed distance, above the versed sine of the difference of observed altitudes. The figures in the above-mentioned sum must be increased to five, if necessary, by prefixing cyphers to the left hand of them. Place the first figure of the sum under the third figure of the excess from the right hand, the

second figure under the fourth figure of the excess, &c., thus inverting the figures of the sum. The product found according to the method of contracted decimal multiplication, is to be subtracted from the excess.

Example I.

Sun's altitude	19°	4′	Observed distance	-	103° 29′ 27″	
Moon's altitude	41	6	Horizontal parallax	-	58 35	
Diff. ob. alt.	22	2				

Prop. log. - 58′ 35″	4875		4875			
41° 6′ A. C. cos.	1229	sin.	1822			
	6104		6697	38′ 30″ arg. tab. 1.		
Parallax in alt.	44′	9″		-		145
Moon's refract.	1	5		Tab. 1		10497
Correction of alt.*	43	4		Tab. 2	-	78
	41°	6		Tab. 4	-	19
Sun's refract.		2	44	Tab. 5	-	0
	41	51	48	-	-	10739
Sun's alt. + paral.	19	4	8			
Diff. true alt. -	22	47	40			

* The correction of the moon's apparent altitude is found by inspection in Table VIII of the following tables. The refraction of all the heavenly bodies is given in Table V, in the column entitled refraction of the stars; and consequently the moon's parallax is the sum of the numbers in this column, and those corresponding to the same altitudes in Table VIII. The parallax of the sun is the difference of the numbers in the same column of Table V, and those in the preceding column, which may easily be taken by inspection. Thus, in the above example, the correction of the moon's apparent altitude, taken from Table VIII, is 43′ 3″, differing one second from that found by the above calculation; which, however, is not sufficient to cause any difference in the corresponding number (78) taken from the annexed Table 2. The refraction answering to 41° 6′, in the third column of Table V, is 1′ 6″; and consequently 43′ 3″ + 1′ 6″ = 44′ 9″, the moon's parallax as above. The correction of the sun's apparent altitude, in the second column of this table, is 2′ 37″, and his refraction, in the third column, is 2′ 45″; and therefore his parallax is 2′ 45″ — 2′ 37″ = 8, as above.

Vers. sin.	103° 29′ -	1233162	log.	10739	8·03100
Vers. sin.	22 2	73034	log.	1160100	6·06446
		1160128	log.	12458	4·02546
		12458			
		1147670	Without logarithms.		
Vers. sin.	22° 47′	78024		11604	
	40″	74		93701	
Vers. sin.	103° 2′ 52″	1225768		11604	
	+ 27			812	
	103° 3′ 19″	TRUE DIST. *required*		35	
				10	
				12458	

Example II.

Star's obs. alt.	11° 17′	Observed distance -	43° 35′ 42″
Moon's obs. alt. -	9 38	Horizontal parallax -	54 42
Diff. obs. alt. -	1 39		

Prop. log. - 54′ 42″	5173	5173	
A. C. 9° 38′	0062	sin. 7764	
	5235	1·2937	9′ 9″ arg. tab. 1.

Parallax in alt.	53′ 54″		44
Moon's refract.	5 26	Tab. 1.	2061
Correction of alt.	48 28	Tab. 2.	100
Star's refract.	4 40	Tab. 3.	11
Moon's alt.	9 38 0	Tab. 5.	11
	10 31 18		2227
	11 17		
Diff. true alt.	0 45 52		

Vers. sin.	43° 35′		275628	Log.	2227	-	7·34772
Vers. sin.	1 19		415	Log.	275200	-	5·43965
			275213	Log.	613	-	2·78737
			613				
			274600				
Vers. sin.	0° 45′		86				
		52″	3				
Vers. sin.	43° 30′ 19″		274689				
	+	42					
	43° 31′ 1″	TRUE DISTANCE.					

Without Logarithms.

2752
72220
550
55
6
2

TABLE I.

ARGUMENT. *Parallax answering to the Complement of the Moon's apparent altitude.*

″ of arg.	Arg. ′&″	′ of arg.	″ of arg.	Arg. ′&″	′ of arg.
3	1		155	32	8752
10	2	25	160	33	9043
15	3	316	165	34	9333
19	4	606	169	35	9624
24	5	897	174	36	9915
29	6	1188	179	37	10206
34	7	1479	184	38	10497
39	8	1770	189	39	10788
44	9	2061	194	40	11079
48	10	2352	199	41	11370
53	11	2643	204	42	11661
58	12	2934	209	43	11952
63	13	3224	213	44	12224
68	14	3515	218	45	12533
73	15	3806	223	46	12824
78	16	4097	228	47	13115
83	17	4388	233	48	13406
88	18	4679	238	49	13697
93	19	4970	242	50	13988
97	20	5261	247	51	14279
102	21	5552	252	52	14570
107	22	5843	257	53	14861
112	23	6133	262	54	15151
116	24	6424	267	55	15442
121	25	6715	272	56	15733
126	26	7006	276	57	16024
131	27	7297	281	58	16315
135	28	7588	286	59	16606
140	29	7879	291	60	16896
145	30	8170		61	17187
150	31	8461		62	17478

TABLE II.

ARGUMENT. *Correction of the Moon's apparent altitude.*

Arg. ′	″	Arg. ′	″
1	0	29	35
2	0	30	38
3	0	31	40
4	1	32	43
5	1	33	46
6	1	34	49
7	2	35	52
8	2	36	55
9	3	37	58
10	4	38	61
11	5	39	64
12	6	40	68
13	7	41	71
14	8	42	74
15	10	43	78
16	11	44	82
17	12	45	86
18	13	46	90
19	15	47	94
20	17	48	98
21	18	49	102
22	19	50	106
23	21	51	110
24	23	52	114
25	26	53	118
26	28	54	123
27	30	55	128
28	32	56	131

TABLE IV.

ARGUMENT. *Sun's apparent altitude.*

Arg. 0′	″
3·0	67
3·15	59
3·30	53
3·45	48
4·00	45
4·30	38
5·0	33
6·0	27
7·0	22
8·0	20
9·0	19
10·0	18
15·0	17
20·0	19
25·0	20
30·0	21
35·0	24
40 0	27
50·0	33
60·0	37
70·0	41
80·0	42
90·0	43

TABLE III.

ARGUMENT. *Star's apparent altitude.*

Arg. 0′	″
3·00	65
3·15	57
3·30	51
3·45	46
4·00	42
4·30	[illegible]
5 00	[illegible]
6·0	[illegible]
7·0	18
8·0	15
9·0	13
10·0	11
15·0	6
20·0	4
25·0	2
30·0	0
90·0	0

TABLE V.

ARGUMENT. *Moon's apparent altitude.*

Arg. 0′	″
3·00	55
3·15	48
3·30	43
3·45	39
4·00	36
4·30	30
5·0	26
6·0	20
7·0	16
8·0	13
9·0	11
10·0	10
15·0	6
20·0	4
25·0	2
30·0	0
90·0	0

TABLE

OF

NATURAL VERSED SINES

TO EVERY MINUTE

OF THE

FIRST QUADRANT.

′	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	′
0	000000	000152	000609	001370	002436	003805	005478	007454	009732	012312	0
1	000000	000157	000619	001386	002456	003831	005509	007489	009772	012357	1
2	000000	000163	000630	001401	002477	003856	005539	007525	009813	012403	2
3	000000	000168	000640	001416	002497	003882	005570	007561	009854	012449	3
4	000001	000173	000650	001432	002518	003907	005600	007595	009894	012494	4
5	000001	000179	000661	001448	002538	003933	005631	007632	009935	012540	5
6	000002	000184	000672	001463	002559	003959	005662	007668	009976	012586	6
7	000002	000190	000682	001479	002580	003985	005693	007704	010017	012632	7
8	000003	000196	000693	001495	002601	004011	005724	007740	010058	012678	8
9	000003	000201	000704	001511	002622	004037	005755	007776	010100	012725	9
10	000004	000207	000715	001527	002643	004063	005786	007813	010141	012771	10
11	000005	000213	000726	001543	002664	004089	005818	007849	010182	012817	11
12	000006	000219	000737	001559	002685	004116	005849	007885	010224	012864	12
13	000007	000225	000748	001575	002707	004142	005880	007922	010265	012910	13
14	000008	000232	000760	001592	002728	004168	005912	007958	010307	012957	14
15	000010	000238	000771	001608	002750	004195	005944	007995	010349	013004	15
16	000011	000244	000782	001625	002771	004222	005975	008032	010390	013050	16
17	000012	000251	000794	001641	002793	004248	006007	008069	010432	013097	17
18	000014	000257	000806	001658	002815	004275	006039	008106	010474	013144	18
19	000015	000264	000817	001675	002837	004302	006071	008143	010516	013191	19
20	000017	000271	000829	001692	002859	004329	006103	008180	010558	013238	20
21	000019	000278	000841	001709	002881	004356	006135	008217	010601	013286	21
22	000020	000284	000853	001726	002903	004383	006167	008254	010643	013333	22
23	000022	000291	000865	001743	002925	004411	006200	008291	010685	013380	23
24	000024	000299	000877	001760	002947	004438	006232	008329	010728	013428	24
25	000026	000306	000889	001777	002970	004465	006264	008366	010770	013475	25
26	000029	000313	000902	001795	002992	004493	006297	008404	010813	013523	26
27	000031	000320	000914	001812	003015	004520	006330	008442	010855	013571	27
28	000033	000328	000927	001830	003037	004548	006362	008479	010898	013618	28
29	000036	000335	000939	001847	003060	004576	006395	008517	010941	013666	29
30	000038	000343	000952	001865	003083	004604	006428	008555	010984	013714	30
31	000041	000350	000964	001883	003105	004632	006461	008593	011027	013762	31
32	000043	000358	000977	001901	003128	004660	006494	008631	011070	013811	32
33	000046	000366	000990	001919	003151	004688	006527	008669	011113	013859	33
34	000049	000374	001003	001937	003175	004716	006560	008708	011157	013907	34
35	000052	000382	001016	001955	003198	004744	006594	008746	011200	013955	35
36	000055	000390	001029	001973	003221	004773	006627	008784	011244	014004	36
37	000058	000398	001043	001992	003244	004801	006661	008823	011287	014052	37
38	000061	000406	001056	002010	003268	004829	006694	008862	011330	014101	38
39	000064	000415	001069	002028	003291	004858	006728	008900	011374	014150	39
40	000068	000423	001083	002047	003315	004887	006762	008939	011418	014199	40
41	000071	000431	001096	002066	003339	004916	006795	008978	011462	014248	41
42	000075	000440	001110	002084	003363	004944	006829	009017	011506	014296	42
43	000078	000449	001124	002103	003386	004973	006863	009056	011550	014346	43
44	000082	000458	001138	002122	003410	005002	006897	009095	011594	014395	44
45	000086	000466	001152	002141	003434	005031	006931	009134	011638	014444	45
46	000089	000475	001166	002160	003459	005061	006966	009173	011683	014493	46
47	000093	000484	001180	002179	003483	005090	007000	009213	011727	014543	47
48	000097	000493	001194	002198	003507	005119	007034	009252	011772	014592	48
49	000102	000503	001208	002218	003531	005149	007069	009292	011816	014642	49
50	000106	000512	001222	002237	003556	005178	007103	009331	011861	014691	50
51	000110	000521	001237	002257	003580	005208	007138	009371	011905	014741	51
52	000114	[illegible]	001251	002276	003605	005237	007173	009411	011950	014791	52
53	000119	[illegible]	001266	002296	003630	005267	007208	009451	011995	014841	53
54	000123	000550	001281	002316	003655	005297	007243	009490	012040	014891	54
55	000128	000559	001295	002335	003680	005327	007278	009531	012085	014941	55
56	000133	000569	001310	002355	003705	005357	007313	009571	012130	014991	56
57	000137	000579	001325	002375	003730	005387	007348	009611	012175	015041	57
58	000142	000589	001340	002395	003755	005417	007383	009651	012221	015091	58
59	000147	000599	001355	002416	003780	005448	007418	009691	012266	015142	59

′	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	′
0	015192	018373	021852	025630	029704	034074	038738	043695	048943	054481	0
1	015243	018428	021913	025695	029775	034149	038818	043780	049033	054576	1
2	015293	018484	021973	025761	029845	034225	038899	043865	049123	054671	2
3	015344	018540	022034	025827	029916	034300	038979	043951	049213	054766	3
4	015395	018595	022095	025892	029986	034376	039060	044036	049304	054861	4
5	015446	018651	022156	025958	030057	034452	039140	044122	049394	054956	5
6	015497	018707	022217	026024	030128	034527	039221	044207	049484	055051	6
7	015548	018763	022278	026090	030199	034603	039301	044293	049575	055146	7
8	015599	018819	022339	026156	030270	034679	039382	044378	049665	055242	8
9	015650	018876	022400	026222	030341	034755	039463	044464	049756	055337	9
10	015701	018932	022461	026288	030412	034831	039544	044550	049846	055432	10
11	015753	018988	022523	026355	030483	034907	039625	044636	049937	055528	11
12	015804	019045	022584	026421	030555	034983	039706	044722	050028	055624	12
13	015856	019101	022646	026488	030626	035060	039787	044808	050119	055719	13
14	015908	019158	022707	026554	030697	035136	039869	044894	050210	055815	14
15	015959	019215	022769	026621	030769	035213	039950	044980	050301	055911	15
16	016011	019271	022831	026687	030841	035289	040032	045066	050392	056007	16
17	016063	019328	022992	026754	030912	035366	040113	045153	050483	056103	17
18	016115	019385	022954	026821	030984	035443	040195	045239	050574	056199	18
19	016167	019442	023016	026888	031056	035519	040276	045326	050666	056295	19
20	016219	019499	023078	026955	031128	035596	040358	045412	050757	056391	20
21	016271	019557	023141	027022	031200	035673	040440	045499	050849	056488	21
22	016324	019614	023203	027089	031272	035750	040522	045586	050940	056584	22
23	016376	019671	023265	027157	031344	035827	040604	045673	051032	056681	23
24	016429	019729	023328	027224	031417	035905	040686	045760	051124	056777	24
25	016481	019786	023390	027292	031489	035982	040768	045847	051216	056874	25
26	016534	019844	023453	027359	031562	036059	040850	045934	051308	056971	26
27	016586	019902	023515	027427	031634	036137	040933	046021	051400	057068	27
28	016639	019959	023578	027494	031707	036214	041015	046108	051492	057164	28
29	016692	020017	023641	027562	031780	036292	041098	046196	051584	057261	29
30	016745	020075	023704	027630	031852	036369	041180	046283	051676	057358	30
31	016798	020133	023767	027698	031925	036447	041263	046371	051769	057456	31
32	016851	020191	023830	027766	031998	036525	041346	046458	051861	057553	32
33	016904	020250	023893	027834	032071	036603	041428	046546	051954	057650	33
34	016958	020308	023956	027902	032144	036681	041511	046634	052046	057747	34
35	017011	020366	024020	027971	032217	036759	041594	046721	052139	057845	35
36	017065	020425	024083	028039	032291	036837	041677	046809	052232	057942	36
37	017118	020483	024147	028107	032364	036916	041761	046897	052324	058040	37
38	017172	020542	024210	028176	032438	036994	041844	046985	052417	058138	38
39	017226	020601	024274	028245	032511	037072	041927	047074	052510	058236	39
40	017279	020659	024338	028313	032585	037151	042011	047162	052603	058333	40
41	017333	020718	024401	028382	032658	037230	042094	047250	052696	058431	41
42	017387	020777	024465	028451	032732	037308	042177	047338	052790	058529	42
43	017441	020836	024529	028520	032806	037387	042261	047427	052883	058628	43
44	017495	020895	024593	028589	032880	037466	042345	047516	052976	058726	44
45	017550	020954	024658	028658	032954	037545	042429	047604	053070	058824	45
46	017604	021014	024722	028727	033028	037624	042512	047693	053163	058922	46
47	017658	021073	024786	028796	033102	037703	042596	047782	053257	059021	47
48	017713	021133	024851	028866	033177	037782	042680	047871	053351	059119	48
49	017767	021192	024915	028935	033251	037861	042765	047960	053444	059218	49
50	017822	021252	024980	029005	033325	037941	042849	048049	053538	059316	50
51	017877	021311	025044	029074	033400	038020	042933	048138	053632	059415	51
52	017931	021371	025109	029144	033474	038099	043017	048227	053726	059514	52
53	017986	021431	025174	029214	033549	038179	043102	048316	053820	059613	53
54	018041	021491	025239	029283	033624	038259	043186	048406	053915	059712	54
55	018096	021551	025304	029353	033699	038338	043271	048495	054009	059811	55
56	018151	021611	025369	029423	033774	038418	043356	048585	054103	059910	56
57	018207	021671	025434	029493	033849	038498	043440	048674	054198	060009	57
58	018262	021732	025499	029564	033924	038578	043525	048764	054292	060109	58
59	018317	021792	025564	029634	033999	038658	043610	048854	054387	060208	59

′	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	′
0	060307	066420	072816	079495	086454	093692	101306	108993	117052	125380	0
1	060407	066524	072925	079609	086573	093815	101334	109126	117189	125521	1
2	060506	066628	073034	079723	086691	093938	101461	109258	117326	125662	2
3	060606	066733	073143	079836	086810	094061	101589	109391	117463	125804	3
4	060706	066837	073253	079950	086929	094185	101717	109524	117599	125945	4
5	060806	066942	073362	080064	087047	094308	101845	109657	117736	126086	5
6	060906	067046	073471	080178	087166	094431	101972	109789	117873	126228	6
7	061006	067151	073581	080293	087285	094555	102100	109922	118010	126369	7
8	061106	067256	073690	080407	087403	094678	102228	110055	118147	126511	8
9	061206	067361	073800	080521	087522	094802	102357	110185	118284	126652	9
10	061306	067466	073910	080636	087642	094925	102485	110318	118422	126794	10
11	061407	067571	074019	080750	087761	095049	102613	110451	118559	126936	11
12	061507	067676	074129	080865	087880	095173	102742	110584	118696	127078	12
13	061607	067781	074239	080979	087999	095297	102870	110717	118834	127220	13
14	061708	067887	074349	081094	088118	095421	102999	110850	118971	127362	14
15	061808	067992	074459	081209	088238	095545	103127	110983	119109	127504	15
16	061909	068098	074570	081324	088357	095669	103256	111116	119247	127646	16
17	062010	068203	074680	081439	088477	095793	103385	111249	119385	127788	17
18	062111	068309	074790	081554	088597	095917	103514	111383	119523	127931	18
19	062212	068414	074901	081669	088716	096042	103642	111516	119661	128073	19
20	062313	068520	075011	081784	088836	096166	103771	111650	119799	128216	20
21	062414	068626	075122	081899	088956	096291	103901	111783	119937	128358	21
22	062515	068732	075232	082014	089076	096415	104030	111917	120075	128501	22
23	062617	068838	075343	082130	089196	096540	104159	112051	120214	128643	23
24	062718	068944	075454	082245	089316	096665	104288	112185	120352	128786	24
25	062819	069050	075565	082361	089436	096789	104418	112318	120490	128929	25
26	062921	069157	075676	082477	089557	096914	104547	112452	120628	129072	26
27	063022	069263	075787	082592	089677	097039	104677	112587	120767	129215	27
28	063124	069369	075898	082708	089798	097164	104806	112721	120905	129358	28
29	063226	069476	076009	082824	089918	097289	104936	112855	121044	129501	29
30	063328	069582	076120	082940	090039	097415	105066	112989	121183	129644	30
31	063430	069689	076232	083056	090159	097540	105195	113123	121322	129788	31
32	063532	069796	076343	083172	090280	097666	105325	113258	121461	129931	32
33	063634	069902	076455	083288	090401	097791	105455	113392	121600	130074	33
34	063736	070009	076566	083404	090522	097916	105585	113527	121739	130218	34
35	063838	070116	076678	083521	090643	098042	105716	113662	121878	130361	35
36	063940	070225	076790	083637	090764	098167	105846	113796	122017	130505	36
37	064043	070331	076902	083754	090885	098293	105976	113931	122156	130649	37
38	064145	070438	077013	083870	091006	098419	106107	114066	122296	130793	38
39	064248	070545	077125	083987	091127	098545	106237	114201	122435	130936	39
40	064350	070653	077238	084104	091249	098671	106367	114336	122575	131080	40
41	064453	070760	077350	084220	091370	098797	106498	114471	122714	131224	41
42	064556	070867	077462	084337	091492	098923	106629	114606	122854	131368	42
43	064659	070975	077574	084454	091613	099049	106759	114742	122994	131513	43
44	064762	071082	077687	084571	091735	099175	106890	114877	123133	131657	44
45	064865	071190	077799	084688	091857	099301	107021	115012	123273	131801	45
46	064968	071298	077912	084805	091979	099428	107152	115148	123413	131946	46
47	065071	071406	078024	084922	092100	099555	107283	115283	123553	132090	47
48	065174	071514	078137	085040	092222	099681	107414	115419	123693	132234	48
49	065278	071622	078250	085158	092345	099808	107545	115555	123833	132379	49
50	065381	071730	078362	085275	092467	099935	107677	115690	123974	132524	50
51	065485	071839	078475	085393	092589	100061	107808	115826	124114	132669	51
52	065588	071947	078588	085510	092711	100188	107939	115962	124254	132813	52
53	065692	072055	078701	085628	092833	100315	108071	116098	124395	132958	53
54	065795	072164	078815	085746	092956	100442	108202	116234	124535	133103	54
55	065899	072272	078928	085864	093078	100569	108334	116370	124676	133248	55
56	066003	072381	079041	085982	093201	100696	108466	116507	124817	133393	56
57	066107	072490	079154	086100	093324	100824	108597	116643	124957	133539	57
58	066211	072598	079268	086218	093446	100951	108729	116779	125098	133684	58
59	066315	072707	079381	086336	093569	101078	108861	116916	125239	133829	59

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2	134266	143132	152260	161646	171288	181182	191325	201715	212348	223220	2
3	134413	[illegible]	152415	161805	171451	181349	191496	201890	212527	223403	3
4	134559	[illegible]	152569	161964	171614	181516	191667	202065	212706	223587	4
5	134705	[illegible]	152725	162122	171777	181683	191839	202241	212885	223770	5
6	134849	[illegible]	152878	162281	171940	181850	192010	202416	213065	[illegible]	6
7	[illegible]	143885	153033	162440	172103	182018	192181	202592	213244	[illegible]	7
8	135140	144034	153187	162599	172266	182185	192353	202767	213424	224321	8
9	135287	144184	153342	162758	172429	182352	192525	202943	213604	224504	9
10	135433	144334	153497	162917	172593	182520	192696	203118	213783	224688	10
11	135579	144485	153652	163076	172756	182687	192868	203294	213963	224872	11
12	135725	144636	153807	163236	172919	182855	193040	203470	214143	225055	12
13	135872	144786	153962	163395	173083	183023	193211	203646	214323	225239	13
14	136018	144937	154117	163554	173247	183191	193383	203822	214503	[illegible]	14
15	136164	145088	154272	163714	173410	183358	193555	203998	214683	[illegible]	15
16	136311	145239	154427	163873	173574	183526	193727	204174	214863	[illegible]	16
17	136458	145390	154583	164033	173738	183694	193899	204350	215043	[illegible]	17
18	136604	145541	154738	164193	173902	183862	194072	204526	215224	[illegible]	18
19	136751	145692	154894	164352	174066	184030	194244	204703	215404	[illegible]	19
20	136898	145844	155049	164512	174230	184199	194416	204879	215584	[illegible]	20
21	137045	145995	155205	164672	174394	184367	194589	205056	215765	226713	21
22	137192	146146	155360	164832	174558	184535	194761	205232	215945	226897	22
23	137339	146298	155516	164992	174722	184704	194934	205409	216126	227082	23
24	137486	146449	155672	165152	174886	184872	195106	205585	216306	227266	24
25	137633	146601	155828	165312	175051	185041	195279	205762	216487	227451	25
26	137781	146752	155984	165472	175215	185209	195452	205939	216668	227636	26
27	137928	146904	156140	165633	175380	185378	195624	206116	216849	227821	27
28	138076	147056	156296	165793	175544	185547	195797	206293	217030	228005	28
29	138223	147208	156452	165954	175709	185716	195970	206470	217211	228190	29
30	138371	[illegible]	156609	166114	175874	[illegible]	196143	206647	217392	228375	30
31	138518	[illegible]	156765	166275	176039	[illegible]	196316	206824	217573	228560	31
32	138666	[illegible]	156921	166435	176203	186222	196489	207001	217754	228746	32
33	138814	147816	157078	166596	176368	186392	196663	207178	217935	228931	33
34	138962	147968	157234	166757	176533	186561	196836	207356	218117	229116	34
35	139110	148121	157391	166918	176698	186730	197009	207533	218298	229301	35
36	139258	148273	157548	167079	176864	186899	197182	207710	218479	229487	36
37	139406	148425	157704	167240	177029	187069	197356	207888	218661	229672	37
38	139554	148578	157861	167401	177194	187238	197529	208065	218843	229858	38
39	139702	148731	158018	167562	177359	187407	197703	208243	219024	230043	39
40	139851	148883	158175	167723	177525	187577	197877	208421	219206	230229	40
41	139999	149036	158332	167884	177690	187747	198050	208599	219388	230415	41
42	140148	149189	158489	168046	177856	187916	198224	208776	219570	230600	42
43	140296	149342	158646	168207	178022	188086	198398	208954	219751	230786	43
44	140445	149495	158804	168369	178187	188256	198572	209132	219933	230972	44
45	140594	149648	158961	168530	178353	188426	198746	209310	220115	231158	45
46	140742	149801	159118	168692	178519	188596	198920	209488	220298	231344	46
47	140891	149954	159276	168854	178685	188766	199094	209667	220480	231530	47
48	141040	150107	159433	169015	178851	188936	199269	209845	220662	231716	48
49	141189	150261	159591	169177	179017	189106	199443	210023	220844	231903	49
50	141338	150414	159749	169339	179183	189277	199617	210202	221027	232089	50
51	141487	150567	159906	169501	179349	189447	199792	210380	221209	232275	51
52	141636	150721	160064	169663	179515	189617	199966	210559	221392	232462	52
53	141786	150875	160222	169825	179682	189788	200141	210737	221574	232648	53
54	141935	151028	160380	169988	179848	189958	200315	210916	221757	232835	54
55	142084	151182	160538	170150	180015	190129	200490	211095	221940	233021	55
56	142234	151336	160696	170312	180181	190300	200665	211273	222122	233208	56
57	142384	151490	160854	170475	180348	190470	200840	211452	222305	233395	57
58	142533	151644	161013	170637	180514	190641	201014	211631	222488	233582	58
59	142683	151798	161171	170100	180681	190812	201189	211810	222671	233769	59

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2	234330	[illegible]	257245	[illegible]	281064	293305	305780	[illegible]	331302	[illegible]	2
3	234517	245863	257439	269242	281267	293511	305970	[illegible]	[illegible]	[illegible]	3
4	234704	246054	257634	269440	[illegible]	293716	306179	[illegible]	[illegible]	[illegible]	4
5	234891	246245	257829	269639	[illegible]	293922	[illegible]	[illegible]	[illegible]	[illegible]	5
6	235079	246437	258024	269838	281874	294128	306598	[illegible]	[illegible]	[illegible]	6
7	[illegible]	[illegible]	258219	270036	[illegible]	294334	306808	[illegible]	[illegible]	[illegible]	7
8	235453	246819	[illegible]	270235	282279	[illegible]	307017	[illegible]	[illegible]	[illegible]	8
9	235641	247011	258609	270434	[illegible]	294747	307227	319919	[illegible]	345919	9
10	235829	247202	258805	270633	[illegible]	294953	307437	320132	333034	346139	10
11	236016	[illegible]	259000	270832	282887	295159	[illegible]	320345	333251	[illegible]	11
12	236204	[illegible]	259195	271031	283089	295366	307857	[illegible]	[illegible]	[illegible]	12
13	236392	247777	259391	271230	283292	295572	308067	320772	[illegible]	[illegible]	13
14	236580	247968	259586	271430	283495	295779	308277	320986	[illegible]	347020	14
15	236767	248160	259782	271629	283698	295985	308487	[illegible]	334118	347240	15
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17	[illegible]	248544	260173	272028	284104	[illegible]	[illegible]	321627	334552	347681	17
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19	237520	248928	260565	272427	284510	296812	309328	322054	334987	348122	19
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23	238273	249697	261348	273225	285324	297640	310170	322910	335856	[illegible]	23
24	[illegible]	249889	261545	273425	285527	297847	310380	323124	336074	[illegible]	24
25	238650	250084	261741	273625	285731	298054	310591	[illegible]	336291	[illegible]	25
26	238839	250274	261937	273825	285934	298261	310802	323532	336509	349668	26
27	239028	250466	262133	274025	286138	298469	311013	323767	336727	349889	27
28	239216	250659	262330	274225	286342	298676	311223	323981	336944	[illegible]	28
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32	239972	251430	263116	275026	[illegible]	299506	312067	[illegible]	[illegible]	[illegible]	32
33	240161	251623	263312	275227	[illegible]	299713	312279	325053	[illegible]	351216	33
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35	240539	252009	263706	275628	287770	300129	312701	325483	338470	351659	35
36	240729	252202	263903	275828	287974	300337	312912	325698	338688	351880	36
37	240918	252395	264100	276029	288178	300544	313124	325912	338906	[illegible]	37
38	241107	252588	264297	276229	288383	300752	313335	326127	339125	352323	38
39	241297	252782	264494	276430	[illegible]	[illegible]	313547	326342	339343	352545	39
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43	242055	253555	265283	277234	289405	301793	314393	327203	340217	353432	43
44	242245	253749	265480	277435	[illegible]	302001	314605	327418	340435	353654	44
45	242435	253943	265677	277636	289815	302209	[illegible]	327633	340654	353876	45
46	242625	254136	265875	[illegible]	290019	302418	315029	327848	340873	[illegible]	46
47	242815	254330	266072	[illegible]	290224	302626	315241	[illegible]	341092	354320	47
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49	243195	254718	266468	278441	290634	303044	315665	328495	341529	354764	49
50	243385	254912	266665	278643	290839	303252	315877	328710	341748	354987	50
51	243575	255106	266863	278844	291044	303461	316089	328926	341967	355209	51
52	243766	255300	267061	279046	291250	303669	316302	329142	342186	355431	52
53	243956	255494	267259	279247	291455	303878	316514	329358	342406	355654	53
54	244146	255688	267457	279449	291660	304087	316726	329573	342625	355876	54
55	244337	[illegible]	267655	279651	291865	304296	316939	329789	342844	356099	55
56	244528	[illegible]	267853	279852	[illegible]	304505	[illegible]	330005	343063	356321	56
57	244718	[illegible]	268051	280054	[illegible]	304714	[illegible]	330221	343283	356544	57
58	244909	256466	268250	280256	292482	304923	[illegible]	330437	343502	[illegible]	58
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2	357658	371132	384797	398650	412685	426900	441289	455849	470574	485461	2
3	357881	371358	385026	398882	412921	427139	441531	456093	470821	485710	3
4	358104	371584	385256	399115	413156	427377	441772	456337	471068	485960	4
5	358327	371811	385485	399347	413392	427616	442013	456581	471315	486209	5
6	358550	372037	385715	399580	413628	427854	442255	456826	471562	486459	6
7	358774	372263	385944	399812	413863	428093	442496	457070	471809	486708	7
8	358997	372490	386174	400045	414099	428331	442738	457314	472056	486958	8
9	359220	372716	386404	400278	414335	428570	442979	457558	472303	487208	9
10	359443	372943	386633	400511	414571	428809	443221	457803	472550	487457	10
11	359667	373169	386863	400744	414806	429048	443463	458047	472797	487707	11
12	359890	373396	387093	400976	415042	429286	443704	458292	473044	487957	12
13	360114	373623	387322	401209	415278	429525	443946	458536	473291	488207	13
14	360337	373850	387552	401442	415514	429764	444188	458781	473539	488457	14
15	360561	374076	387783	401675	415750	430003	444130	459025	473786	488707	15
16	360785	374303	388013	401908	415986	430242	444672	459270	474033	488957	16
17	361008	374530	388245	402142	416222	430481	444914	459515	474281	489207	17
18	361232	374757	388473	402375	416459	430720	445156	459760	474528	489457	18
19	361456	374984	388703	402608	416695	430960	445398	460004	474776	489707	19
20	361680	375211	388933	402841	416931	431199	445640	460249	475023	489957	20
21	361904	375439	389164	402075	417168	431438	445882	460494	475271	490208	21
22	362128	375666	389394	402308	417404	431677	446124	460739	475519	490458	22
23	362352	375893	389624	403542	417640	431917	446366	460984	475766	490708	23
24	362576	376120	389855	403775	417877	432156	446608	461229	476014	490959	24
25	362800	376348	390085	404009	418114	432396	446851	461474	476262	491209	25
26	363024	376575	390316	404242	418350	432635	447093	461719	476510	491459	26
27	363249	376803	390546	404476	418587	432875	447335	461965	476758	491710	27
28	363473	377030	390777	404710	418823	433114	447578	462210	477005	491960	28
29	363697	377258	391008	404943	419060	433354	447820	462455	477253	492211	29
30	363922	377485	391239	405177	419297	433594	448063	462700	477501	492462	30
31	364146	377713	391469	405411	419534	433833	448306	462946	477749	492712	31
32	364371	377941	391700	405645	419771	434073	448548	463191	477998	492963	32
33	364595	378168	391931	405879	420008	434313	448791	463437	478246	493214	33
34	364820	378396	392162	406113	420245	434553	449034	463682	478494	493464	34
35	365045	378624	392393	406347	420482	434793	449276	463928	478742	493715	35
36	365269	378852	392624	406581	420719	435033	449519	464173	478990	493966	36
37	365494	379080	392855	406815	420956	435273	449762	464419	479239	494217	37
38	365719	379308	393086	407049	421193	435513	450005	464664	479487	494468	38
39	365944	379536	393318	407284	421430	435753	450248	464910	479735	494719	39
40	366169	379764	393549	407518	421668	435993	450491	465156	479984	494970	40
41	366394	379993	393780	407752	421905	436233	450734	465402	480232	495221	41
42	366649	380221	394012	407987	422142	436474	450977	465648	480481	495472	42
43	366844	380449	394243	408221	422380	436714	451220	465895	480729	495723	43
44	367069	380678	394474	408456	422617	436955	451463	466139	480978	495975	44
45	367295	380906	394706	408690	422855	437195	451707	466385	481227	496226	45
46	367520	381134	394938	408925	423092	437435	451950	466631	481475	496477	46
47	367745	381363	395169	409160	423330	437676	452193	466878	481724	496729	47
48	367971	381592	395401	409394	423568	437917	452437	467124	481973	496980	48
49	368196	381820	395633	409629	423805	438157	452680	467370	482222	497231	49
50	368422	382049	395864	409864	424043	438398	452924	467616	482471	497483	50
51	368647	382278	396096	410099	424281	438639	453167	467862	482720	497734	51
52	368873	382506	396328	410334	424519	438879	453411	468109	482969	497986	52
53	369098	382735	396560	410569	424757	439120	453654	468355	483218	498238	53
54	369324	382964	396792	410804	424995	439361	453898	468601	483467	498489	54
55	369550	383193	397024	411039	425233	439602	454142	468848	483716	498741	55
56	369776	383422	397256	411274	425471	439843	454385	469094	483965	498993	56
57	370002	383651	397488	411509	425709	440084	454629	469341	484214	499244	57
58	370228	383880	397720	411744	425947	440325	454873	469587	484463	499496	58
59	370454	384109	397953	411979	426185	440566	455117	469834	484713	499748	59

′	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	′
0	500000	515190	530528	546009	561629	577382	593263	609269	625393	641632	0
1	500252	515445	530785	546269	561890	577645	593529	609537	625663	641904	1
2	500504	515699	531042	546528	562152	577909	593795	609804	[illegible]	642175	2
3	500756	515954	531299	546787	562413	578173	594061	[illegible]	[illegible]	642447	3
4	501008	516208	531556	547046	562675	578437	594327	[illegible]	[illegible]	642719	4
5	301260	516463	531813	547306	562937	578700	594592	[illegible]	[illegible]	[illegible]	5
6	501512	516718	532070	547565	563198	578964	594858	[illegible]	[illegible]	[illegible]	6
7	501764	516972	532327	547825	563460	579228	595124	[illegible]	627282	[illegible]	7
8	502017	517227	532584	548084	563722	579492	595390	611412	627552	643806	8
9	502269	517482	532842	548344	563983	579756	595656	611680	627822	644077	9
10	502521	517737	533099	548603	564245	580020	595922	611948	628092	644349	10
11	502774	517991	533356	548863	564507	580284	596189	612216	628362	644621	11
12	503026	518246	533613	549122	564769	580548	596455	612484	628632	644893	12
13	503278	518501	533871	549382	565031	580812	596721	612753	628902	645165	13
14	503531	518756	534128	549642	565293	581076	596987	613021	629172	645437	14
15	503783	519011	534385	549902	565555	581340	597253	613289	629443	645709	15
16	504036	519266	534643	550161	565817	581604	597520	613557	629713	645981	16
17	504289	519521	534900	550421	566079	581869	597786	613826	629983	646253	17
18	504541	519776	535158	550681	566341	582133	598052	614094	630253	646525	18
19	504794	520032	535416	550941	566603	582397	598319	614362	630523	646797	19
20	505047	520287	535673	551201	566865	582661	598585	614631	630794	647069	20
21	505300	520542	535931	551461	567127	582926	598851	614899	631064	647342	21
22	505552	520797	536188	551721	567390	583190	599118	615168	631335	647614	22
23	505805	521053	536446	551981	567652	583455	599384	615436	631605	647886	23
24	506058	521308	536704	552241	567914	583719	599651	615705	631875	648158	24
25	506311	521564	536962	552501	568177	583984	599917	615973	632146	648431	25
26	506564	521819	537220	552761	568439	584248	600184	616242	632416	648703	26
27	506817	522075	537477	553021	568701	584513	600451	616510	632687	648975	27
28	507070	522330	537735	553282	568964	584777	600717	616779	632957	649248	28
29	507323	522586	537993	553542	569226	585042	600984	617048	633228	649520	29
30	507576	522841	538251	553802	569489	585307	601251	[illegible]	[illegible]	649793	30
31	507830	523097	538509	554062	[illegible]	585571	601518	[illegible]	[illegible]	650065	31
32	508083	523353	538767	554323	570014	585836	601784	617854	[illegible]	650338	32
33	508336	523608	539026	554583	570277	586101	602051	618123	634311	650610	33
34	508589	523864	539284	554844	570539	586366	602318	618392	634582	650883	34
35	508843	524120	539542	555104	570802	586631	602585	618661	634852	351155	35
36	509096	524376	539800	555365	571065	586896	602852	618930	635123	651428	36
37	509350	524632	540058	555625	571328	587160	603119	619199	635394	651701	37
38	509603	524888	540317	555886	571590	587425	603386	619468	635665	651973	38
39	509857	525144	540575	556147	571853	587690	603653	619737	635936	652246	39
40	510110	525400	540833	556407	572116	587955	603920	620006	636207	652519	40
41	510364	525656	541092	556668	572379	588220	604187	620275	636478	652791	41
42	510617	525912	541350	556929	572642	588486	604454	620544	636749	653064	42
43	510871	526168	541609	557190	572905	588751	604722	620813	637020	653337	43
44	511125	526424	541867	557450	573168	589016	604989	621082	637291	653610	44
45	511379	526680	542126	557711	573431	589281	605256	621351	637562	653883	45
46	511633	526937	542385	557972	573694	589546	605523	621621	637833	654156	46
47	511886	527193	542643	558233	573957	589812	605791	621890	638104	654429	47
48	512140	527449	542902	558494	574221	590077	606058	622159	638375	654702	48
49	512394	527706	543161	558755	574484	590342	606325	622429	638647	654975	49
50	512648	527962	543420	559016	574747	590608	606593	622698	638918	655248	50
51	512902	528218	543678	559277	575010	590873	606860	622967	639189	655521	51
52	513156	528475	543937	559538	575274	591138	607128	623237	639460	655794	52
53	513410	528731	544196	559800	575537	591404	607395	623506	639732	656067	53
54	513665	528988	544455	560061	575801	591669	607663	623776	640003	656340	54
55	513919	529245	544714	560322	576064	591935	607930	624045	640275	656613	55
56	514173	529501	544973	560583	576327	592201	608198	624315	640546	656887	56
57	514427	529758	545232	560845	576591	592466	608466	624584	640817	657160	57
58	514682	530015	545491	561106	576854	592732	[illegible]	624854	641089	657433	58
59	514936	530272	545750	561367	577118	592998	609001	625124	641360	657706	59

′	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	′
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1	658253	674707	691260	707906	724642	741462	758360	775332	792373	809477	1
2	658527	674982	691536	708185	724922	741743	758643	775616	792657	809762	2
3	658800	675257	691813	708463	725202	742024	758925	775899	792942	810048	3
4	659073	675532	692090	708741	725481	742305	759207	776183	793227	810333	4
5	659347	675807	692367	709019	725761	742586	759490	776496	793511	810619	5
6	659620	676083	692643	709298	726041	742867	759772	776750	793796	810905	6
7	659894	676358	692920	709576	726321	743148	760054	777033	794080	811190	7
8	660167	676633	693197	709854	726600	743429	760337	777317	794365	811476	8
9	660441	676908	693474	710133	726880	743711	760619	777601	794650	811761	9
10	660715	677184	693751	710411	727160	743992	760902	777884	794934	812047	10
11	660988	677459	694028	710690	727440	744273	761184	778168	795219	812333	11
12	661262	677734	694305	710968	727720	744554	761467	778451	795504	812619	12
13	661536	678010	694582	711247	728000	744835	761749	778735	795789	812904	13
14	661809	678285	694859	711525	728280	745117	762032	779019	796073	813190	14
15	662083	678560	695136	711804	728560	745398	762314	779303	796358	813476	15
16	662357	678836	695413	712082	728839	745679	762597	779586	796643	813761	16
17	662631	679111	695690	712361	729119	745961	762879	779870	796928	814048	17
18	662905	679387	695967	712639	729400	746242	763162	780154	797213	814333	18
19	663179	679663	696244	712918	729679	746523	763444	780438	797497	814619	19
20	663452	679938	696521	713197	729960	746805	763727	780721	797782	814905	20
21	663726	680214	696798	713475	730240	747086	764010	781005	798067	815191	21
22	664000	680489	697076	713754	730520	747368	764292	781289	798352	815477	22
23	664274	680765	697353	714033	730800	747649	764575	781573	798637	815763	23
24	664548	681041	697630	714312	731080	747931	764858	781857	798922	816049	24
25	664822	681316	697907	714590	731360	748212	765141	782141	799207	816335	25
26	665097	681592	698185	714869	731641	748494	765423	782424	799492	816620	26
27	665371	681868	698462	715148	731921	748775	765706	782708	799777	816906	27
28	665645	682144	698739	715427	732201	749057	765989	782992	800062	817192	28
29	665919	682419	699017	715706	732481	749338	766272	783276	800347	817478	29
30	666193	682695	699294	715985	732762	749620	766555	783560	800632	817764	30
31	666467	682971	699572	716264	733042	749902	766837	783844	800917	818050	31
32	666742	683247	699849	716542	733322	750183	767120	784128	801202	818336	32
33	667016	683523	700127	716821	733603	750465	767403	784412	801487	818623	33
34	667290	683799	700404	717100	733883	750747	767686	784696	801772	818909	34
35	667564	684075	700682	717379	734163	751028	767969	784981	802057	819195	35
36	667839	684351	700959	717658	734444	751310	768252	785265	802343	819481	36
37	668113	684627	701237	717938	734724	751592	768535	785549	802628	819767	37
38	668388	684903	701514	718217	735005	751874	768818	785833	802913	820053	38
39	668662	685179	701792	718496	735285	752155	769101	786117	803198	820339	39
40	668937	685455	702070	718775	735566	752437	769384	786401	803483	820625	40
41	669211	685731	702347	719054	735846	752719	769667	786685	803769	820911	41
42	669486	686008	702625	719333	736127	753001	769950	786970	804054	821198	42
43	669760	686284	702903	719612	736407	753283	770233	787254	804339	821484	43
44	670035	686560	703181	719892	736688	753565	770516	787538	804624	821770	44
45	670309	686836	703458	720171	736969	753847	770800	787822	804910	822056	45
46	670584	687112	703736	720450	737249	754129	771083	788107	805195	822343	46
47	670859	687389	704014	720730	737530	754411	771366	788391	805480	822629	47
48	671133	687665	704292	721009	737811	754693	771649	788675	805766	822915	48
49	671408	687941	704570	721288	738091	754975	771932	788959	806051	823202	49
50	671683	688218	704848	721568	738372	755257	772216	789244	806336	823488	50
51	671958	688494	705126	721847	738653	755539	772499	789528	806622	823774	51
52	672232	688771	705404	722126	738934	755821	772782	789813	806907	824060	52
53	672507	689047	705682	722406	739215	756103	773065	790097	807193	824347	53
54	672782	689324	705960	722685	739495	756385	773349	790381	807478	824633	54
55	673057	689600	706238	722965	739776	756667	773632	790666	807763	824920	55
56	673332	689877	706516	723244	740057	756949	773915	790950	808049	825206	56
57	673607	690153	706794	723524	740338	757231	774199	791235	808534	825492	57
58	673882	690430	707072	723803	740619	757514	774482	791519	808620	825779	58
59	674157	690706	707350	724083	740900	757796	774765	791804	808905	826065	59

′	80°	81°	82°	83°	84°	85°	86°	87°	88°	89°	′
0	826352	843565	860827	878131	895471	912844	930243	947664	965100	982548	0
1	826638	843853	861115	878419	895761	913134	930534	947954	965391	982838	1
2	826925	844140	861403	878708	896050	913424	930824	948245	965682	983129	2
3	827211	844427	861691	878997	896339	913714	931114	948535	965973	983420	3
4	827498	844715	861979	879286	896629	914003	931404	948826	966263	983711	4
5	827784	845002	862267	879574	896918	914293	931694	949116	966554	984002	5
6	828071	845290	862555	879863	897207	914583	931985	949407	966845	984293	6
7	828357	845577	862844	880152	897497	914873	932275	949698	967136	984583	7
8	828644	845864	863132	880441	897786	915163	932565	949988	967426	984874	8
9	828931	846152	863420	880730	898075	915453	932855	950279	967717	985165	9
10	829217	846439	863708	881018	898365	915742	933146	950569	968008	985456	10
11	829504	846727	863996	881307	898654	916032	933436	950860	968298	985747	11
12	829790	847014	864284	881596	898944	916322	933726	951150	968589	986038	12
13	830077	847302	864573	881885	899233	916612	934016	951441	968880	986329	13
14	830364	847589	864861	882174	899522	916902	934307	951731	969171	986619	14
15	830650	847877	865149	882463	899812	917192	934597	952022	969461	986910	15
16	830937	848164	865437	882751	900101	917482	934887	952312	969752	987201	16
17	831224	848452	865726	883040	900391	917772	935177	952603	970043	987492	17
18	831511	848739	866014	883329	900680	918961	935468	952893	970334	987783	18
19	831797	849027	866302	883618	900970	918351	935758	953184	970624	988074	19
20	832084	849314	866590	883907	901259	918641	936048	953475	970915	988365	20
21	832371	849602	866879	884196	901549	918931	936339	953765	971206	988656	21
22	832658	849889	867167	884485	901838	919221	936629	954056	971497	988946	22
23	832944	850177	867455	884774	902128	919511	936919	954346	971788	989237	23
24	833231	850465	867744	885063	902417	919801	937209	954637	972078	989528	24
25	833518	850752	868032	885352	902707	920091	937500	954928	972369	989819	25
26	833805	851040	868320	885641	902996	920381	937790	955218	972660	990110	26
27	834092	851328	868609	885930	903286	920671	938080	955509	972951	990401	27
28	834379	851615	868897	886219	903575	920961	938371	955799	973241	990692	28
29	834665	851903	869185	886508	903865	921251	938661	956090	973532	990983	29
30	834952	852191	869474	886797	904154	921541	938951	956381	973823	991273	30
31	835239	852478	869762	887086	904444	921831	939242	956671	974114	991564	31
32	835526	852766	870051	887375	904733	922121	939532	956962	974405	991855	32
33	835813	853054	870339	887664	905023	922411	939822	957252	974695	992146	33
34	836100	853341	870627	887953	905312	922701	940113	957543	974986	992437	34
35	836387	853629	870916	888242	905602	922991	940403	957834	975277	992728	35
36	836674	853917	871204	888531	905892	923281	940694	958124	975568	993019	36
37	836961	854205	871493	888820	906181	923571	940984	958415	975859	993310	37
38	837248	854492	871781	889109	906471	923861	941274	958706	976149	993600	38
39	837535	854780	872070	889398	906760	924151	941565	958996	976440	993891	39
40	837822	855068	872358	889687	907050	924441	941855	959287	976731	994182	40
41	838109	855356	872647	889976	907340	924731	942146	959578	977022	994473	41
42	838396	855644	872935	890266	907629	925021	942436	959868	977313	994764	42
43	838683	855932	873224	890555	907919	925311	942726	960159	977603	995055	43
44	838970	856219	873512	890844	908209	925601	943017	960449	977894	995346	44
45	839257	856507	873801	891133	908498	925891	943307	960740	978185	995637	45
46	839544	856795	874090	891422	908788	926182	943598	961031	978476	995928	46
47	839832	857083	874378	891711	909078	926472	943888	961321	978767	996218	47
48	840119	857371	874667	892001	909367	926762	944178	961612	979058	996509	48
49	840406	857659	874955	892290	909657	927052	944469	961903	979348	996800	49
50	840693	857947	875244	892579	909947	927342	944759	962193	979639	997091	50
51	840980	858235	875533	892868	910236	927632	945050	962484	979930	997382	51
52	841267	858523	875821	893157	910526	927922	945340	962775	980221	997673	52
53	841555	858811	876110	893447	910816	928212	945631	963066	980512	997964	53
54	841842	859099	876398	893736	911106	928503	945921	963356	980803	998255	54
55	842129	859387	876687	894025	911395	928793	946212	963647	981093	998546	55
56	842416	859675	876976	894314	911685	929083	946502	963938	981384	998836	56
57	842704	859963	877264	894604	911975	929373	946793	964228	981675	999127	57
58	842991	860251	877553	894893	912265	929663	947083	964519	981966	999418	58
59	843278	860539	877842	895182	912554	929953	947374	964810	982257	999709	59

INTRODUCTION

TO

THE TABLES,

EXPLANATORY OF THEIR CONSTRUCTION AND USE.

BY THE TRANSLATOR.

TABLE I.

Depression of the Horizon.

THE angular distance between the zenith and the horizon of an observer could only be equal to 90° if the surface of the earth were an extended plane, and the eye of the observer situated in that plane. Thus, fig. 6, if the surface of the earth coincided with the line AC, and the observer's eye were at A, a point in that line, and Z in the direction of the observer's zenith, the angle ZAC would be a right angle, or 90°. But as the earth's surface is curved, as shown in this figure, which represents a vertical section of the earth, by a plane passing through the eye of the observer and his zenith, any point P on the surface will be below the horizontal line AC, and consequently if AP be joined the angle ZAP will be greater than 90°. The eye of the observer is always more or less elevated above the point A; let it be at B, where the tangent drawn from the point P meets the vertical line AZ; then as the angle ZBP is equal to the sum of the angles ZAP, APB, and ZAP exceeds 90°, the angle ZBP also exceeds 90°; and if the line BP be drawn parallel to AC, the angle ZBD will evidently be a right angle, and the angle PBD will be the *depression of the horizon*, or the quantity which the angle ZBP, the angular distance between the zenith and horizon of the observer, exceeds 90°.

Now if the vertical line ZA be produced to O, which represents the centre of the earth, and OP be joined, the angles POB, PBD will evidently be equal to each other, and consequently the depression of the horizon may easily be found by the rules of plane trigonometry; for as AB : rad. :: OP : cos. POB = cos. PBD. But when the height AB is small, the common tables of logarithms are not sufficiently extensive to give this angle with the required accuracy, besides which its value still requires a correction on account of refraction.

To avoid both these inconveniences, let D denote the angle of depression PBD, r the mean terrestrial refraction in terms of the observed arc AP, H the height AB of the eye above the surface of the sea in English feet, and R the mean radius of the earth, or that corresponding to 45° of latitude; then, according to Delambre, (*Abrégé d'Astronomie*, p. 626),

$$\tan. D = \left(\frac{1-r}{\sin. 45^\circ}\right) \times \left(\frac{H}{R}\right)^{\frac{1}{2}}.$$

As the arc denoted by D is always very small, it is not sensibly different from its tangent, and therefore may be substituted for it: hence

$$D = \left(\frac{1-r}{\sin. 45^\circ}\right) \times \left(\frac{H}{R}\right)^{\frac{1}{2}}.$$

Now the mean value of r is ·07876, and that of R = 20892710 English feet, or equal to an arc of 206265″; and by substituting these values for their respective letters in the preceding formula, it becomes

$$D = \frac{(1 - {\cdot}07876) \times 206265''}{{\cdot}7071068\,(20892710)^{\frac{1}{2}}} \sqrt{H} = 58''{\cdot}795 \sqrt{H},$$

which is very easily calculated, and does not require any correction.

Hence the following RULE.—*Multiply the square root of the height of the eye in feet by 58″·795, and the product will be the depression in seconds.*

Example.—Suppose H = 18 feet, then $58''{\cdot}795 \sqrt{18} = 249''$ = 4′ 9″; the depression of the horizon when the observer's eye is 18 feet above the surface of the sea. And if H = 25 feet, $58''{\cdot}795 \sqrt{25} = 294''$ = 4′ 54″, the depression in this case.

With respect to the distance that can be seen by an observer elevated above the earth's surface: let AO (fig. 6) the radius of the earth $= r$, AB the height of the eye $= h$; and BP the tangent from the point B $= d$. Then, by geometry, $BP^2 = AB \cdot BD = AB (AB + AD)$, or $d^2 = h (h + 2r)$; and $d = h^{\frac{1}{2}} (h + 2r)^{\frac{1}{2}}$. But as the magnitude of h in all practical cases in navigation is so extremely small with respect to $2r$, the former seldom exceeding one millionth part of the latter, the quantity $(h + 2r)^{\frac{1}{2}}$ may be regarded as a constant quantity; and therefore the value of d will vary as $h^{\frac{1}{2}}$. But in all small arcs the tangent is not sensibly different from the arc itself, and in this case the arc never exceeds a few minutes, d may, without sensible error, be substituted for the arc AP, or the distance that can be seen from the point B; hence this distance varies as the square root of the height of the eye.

Now as it is found from calculation that when the eye is 6 feet above the earth's surface the distance that can be seen is 3 miles, we have $\sqrt{6} : \sqrt{h} :: 3 : \frac{3}{\sqrt{6}} \sqrt{h} = \frac{1}{2} \sqrt{6} \times \sqrt{h} = 1{\cdot}2247 \sqrt{h}$; which is an expression in miles for the distance that can be seen when the height of the eye above the level of the sea is equal to h.

Hence this RULE.—*Multiply the square root of the height of the eye in feet by* 1·2247, *and the product will be the distance that can be seen, in English miles.*

Example.—If $h = 25$ feet, then $1{\cdot}2247 \sqrt{25} = 1{\cdot}2247 \times 5 = 6{\cdot}1235$, or very nearly $6\frac{1}{8}$ miles. And again, if $h = 18$ feet, $12247 \sqrt{18} = 5{\cdot}1959 = 5{\cdot}2$ nearly; and on this principle the numbers in the third column of Table I. have been calculated.

TABLE II.

Augmentation of the Moon's Semidiameter.

As the moon describes her diurnal circle about the earth as a centre, an observer situated on any part of its surface will see

her nearest to him in the zenith and most distant in the horizon; and the difference of these two distances is nearly equal to the radius of the earth, and about $\frac{1}{60}$th of the moon's horizontal distance from the earth's centre. Observations of the moon's apparent diameter, occultations of the fixed stars, and various other circumstances, also prove that the moon's apparent diameter is subject to variation; and since the apparent magnitudes of bodies are inversely as their distances, we have $59 : 60 :: d : \frac{60d}{59} =$ to her semidiameter at the zenith, where d denotes her horizontal semidiameter; and consequently $\frac{1}{59} d =$ the augmentation at the zenith. But this augmentation varies according to the moon's altitude; hence if her altitude be denoted by a, we have $90 : a :: \frac{1}{59} : \frac{1}{5310} ad = \cdot 000188\ ad$ seconds, where a is in degrees and d in seconds of a degree.

RULE.—*Multiply the altitude in degrees, the horizontal semidiameter in seconds of a degree, and the number* ·000188 *together, and the product will be the augmentation required.*

Example.—Required the augmentation of the moon's semidiameter when her altitude is 30°, and her horizontal diameter 15′ 30″. Hence $a = 30$, and $d = 15' 30'' = 930''$; and therefore $\cdot 000188 \times 30 \times 930'' = 5''$ nearly, the required augmentation, as given in the table.

TABLE III.

Diminution of the Equatorial Parallax at different Degrees of Latitude.

If the earth were truly spherical, the horizontal parallax of a heavenly body, the distance of which remained constant, would be the same in all latitudes. But this will not be the case if the earth's radii are unequal, for the horizontal parallax is the angle under which an observer situated at the centre of the heavenly body would see the terrestrial radius. Hence the sine of the horizontal parallax is equal to the quotient of the

terrestrial radius divided by the distance between the centre of the heavenly body and that of the earth; and the equatorial radius being the greatest and the polar radius the least, the horizontal parallax consequently attains its *maximum* at the equator and its *minimum* at the poles. Now as $\frac{1}{309}$ expresses the ellipticity of the earth, the 309th part of the whole parallax will be the difference between these extremes; and the equatorial parallax also varies from about 53′ to 61′; and consequently the diminution on account of latitude increases from 10″·3 to 11″·7, between the equator and the poles. But for all intermediate situations, this diminution varies as the square of the sine of the latitude: hence, if L denote the latitude, D the whole diminution, and d that required at the latitude L, its value will be obtained by this simple logarithmic formula

$$d = \sin.^2 L \times D.$$

Hence this easy Rule.—*Square the sine of the latitude and multiply it by the whole diminution, the product will be the diminution corresponding to that latitude.*

Examples.—If L = 30°, and D = 11″·7, the greatest diminution, then $\sin.^2 30^\circ = \frac{1}{4}$, and $\frac{1}{4} \times 11''\cdot7 = 3''$, very nearly, as given in the table.

Again, if L = 55°, and D = 10″·3, the least diminution, then

Log. of $\sin.^2 55^\circ$	=	− 1·8267290
Log. of 10″·3	=	1·0128372
Log. of 6″·9114	=	0·8395602

Or of 7″ nearly, as in the table.

TABLE IV.

Errors of the Surfaces of the large Mirror, when these Surfaces make an Angle of 1′ with each other.

The rays of light are reflected by the quicksilvered surface of the great mirror, which is the farthest from the objects from which these rays proceed; they consequently traverse the thickness of the glass, and experience a refraction on entering it and a second on emerging from it. Therefore, if the surfaces of this

mirror are not parallel to each other, these refractions will be unequal, and the angles formed by the incident and reflected rays will not be the same; and the observed angles will consequently participate in this defect. These errors also increase with the distance of the two observed bodies from each other, or as the incident and reflected rays are more inclined to the plane of the mirror; and astronomers determine their magnitude by observation. (See *Biot's Astronomy*, vol. i. p. 362). The numbers in this table also furnish the means of calculating the errors of the observed distances for other inclinations of the surfaces, by proportion. For the error in the table, corresponding to the distance observed for verifying the instrument, is to the error in the same table for any other angle, as the error formed by the verification is to a fourth term, which is the error required.

Example.—Suppose the instrument had been verified by two objects 65° distant from each other, and the error ascertained to be 58″, it is required to find the error corresponding to a distance of 95°, the observation being to the right.

Then as 38″ : 1′ 43″ :: 58″ : 2′ 37″, the error required.

TABLE V.

Refraction less Parallax, for 29ⁱⁿ·92 of the Barometer, and 57°·2 of Fahrenheit's Thermometer.

Rays of light change their direction on passing obliquely from one medium to another of a different density; and this effect is called *Refraction*. If the luminous ray pass obliquely from one medium to another of the same nature, but of a different density, and at the point where it passes from the one to the other, a perpendicular be supposed to be drawn to their common surface, the ray on entering the denser medium will approach this perpendicular. Now the atmosphere being composed of an indefinite number of beds or strata of air, the densities of which increase as they approach the surface of the earth, the luminous rays that traverse them obliquely are in-

flected towards the centre of the earth; and hence all the heavenly bodies appear more elevated, on this account, than they really are. This *astronomical refraction* also varies according to the altitude of the heavenly body.

The refractions contained in this table have been calculated from the series given by the celebrated Laplace, in his great work, the *Mécanique Céleste*. The formulæ deduced from these series are,

$$\text{tan. } u = \text{sin. } 2n\text{R} . \text{ tan. } z\,;$$
$$\text{and tan. } nr = \text{tan. } n\text{R} . \text{ tan. } \tfrac{1}{2}u\,;$$

where $n = 3{\cdot}78$, and $n\text{R} = 6867''$.

When z, which denotes the zenith distance, is given, the first equation will give the value of u, and then the second equation will give that of r, the refraction, in seconds of a degree. But as this formula is adapted to the medium pressure of the atmosphere at the surface of the sea, or 29·92 inches, and the temperature of melting ice, or 32° of Fahrenheit's thermometer, it requires a further reduction to bring it to the temperature for which the table has been calculated, which is 57°·2 of Fahrenheit's thermometer. This may be done by multiplying n, the coefficient of r, by 1 added to as many times ·00208 as there are degrees between the freezing point and the given temperature, as indicated by Fahrenheit's thermometer: thus, if these degrees be denoted by d, the formula becomes

$$\text{tan. } (1{\cdot}00208\, dnr) = \text{tan. } n\text{R} . \text{ tan. } \tfrac{1}{2}u.$$

By substituting the given quantities in the two preceding formulæ, and expressing them in words, the following rule will be obtained.

Rule—1. *Add the logarithm cotangent of the observed altitude to* −2·8230506, *and the sum will be the log. tangent of u.*

2. *Add the log. tangent of* ½*u to* −2·5225024, *and the sum will be the log. tangent of an arc, which is to be taken from the table and reduced into seconds.*

3. *Then to the logarithm of this number of seconds, add* −1·4003208, *and the sum will be the logarithm of the number of seconds in the required refraction r.*

Example.—Required the refraction corresponding to an observed altitude of 30°.

$$\begin{aligned}
&\text{1st.—Log. cotan. } 30^\circ = 10{\cdot}2385606\\
&\qquad\qquad\text{add} \quad - \quad \underline{2{\cdot}8230506}\\
&\text{tan. } u = 6^\circ\,34'\,22'' = 9{\cdot}0616112\\
&\text{2d.—Log. tan. } \tfrac{1}{2}u = 3^\circ\,17'\,11'' = 8{\cdot}7590721\\
&\qquad\qquad\text{add} \quad - \quad \underline{2{\cdot}5225024}\\
&\text{tan. } 6'\,34''{\cdot}5 = 394''{\cdot}5 = 7{\cdot}2815745\\
&\text{3d.—Then log. } 394''{\cdot}5 = 2{\cdot}5960470\\
&\qquad\qquad\text{add} \quad - \quad \underline{1{\cdot}4003208}\\
&\text{Log. } 1'\,39'' = 99''{\cdot}167 = 1{\cdot}9963678
\end{aligned}$$

The required refraction at 30° of altitude is therefore equal to 1′ 39″, which is the number in the table.

But the second column of the table contains the refraction of the sun diminished by its parallax, or the results of $r - \text{P}$, where P denotes the parallax. Now the horizontal parallax of the sun is equal to the quotient obtained by dividing the mean radius of the earth by the mean distance between the centres of the earth and sun; and his parallax of altitude is proportional to the sine of his zenith distance or to the cosine of his altitude: therefore

$$\text{sine of the paral. in altitude} = \frac{\text{earth's radius} \times \text{cos. altitude}}{\text{sun's mean distance.}} = \frac{r \text{ cos. } a}{d},$$

by using the initials of the words only. Expressing these quantities in terms of the earth's radius, the formula becomes

$$\text{sin. P} = \frac{1}{23578} \text{ cos. } a = {\cdot}000042413 \text{ cos. } a.$$

Hence this RULE.—*To the number* $-\,5{\cdot}6274930$, *add the logarithm cosine of the altitude, and the sum will be the log. sine of the parallax in altitude.*

Example.—Required the sun's parallax at 30° of altitude.

$$\begin{aligned}
&\text{Log. cos. } 30^\circ = \quad 9{\cdot}9375306\\
&\qquad\quad \text{Add} = -\,\underline{5{\cdot}6274930}\\
&\text{Paral. reqd. } 7'' = \text{Sin. } 5{\cdot}5650236
\end{aligned}$$

Consequently 1′ 39″ − 7″ = 1′ 32″, the number answering to 30° in the second column of the table.

TABLE VI.

Corrections of Refraction relative to Temperature.

The refractions of Table V. are calculated for the medium temperature; but when much accuracy is required, it becomes necessary to correct these refractions for the temperature at the time of the observations. These corrections are calculated by substituting the different values of d in the formula

$$\tan.\ (1\cdot00208\ dnr) = \tan.\ nR\ .\ \tan.\ \tfrac{1}{2} v,$$

and calculating the corresponding refractions; and the difference between these and the refractions answering to the medium temperature, or $57^{\circ}\cdot2$, will give the corrections inserted in this table. These different values of d only cause a variation in the number to be added to the logarithms of the seconds found from the preceding formula. Thus, if the temperature was $78^{\circ}\cdot8$ instead of $57^{\circ}\cdot2$, the value of d would be $78^{\circ}\cdot8 - 32^{\circ} = 46^{\circ}\cdot8$, and the number to be added would be $-1\cdot3821650$. Hence if it were required to find the correction of the refraction at 30° of altitude corresponding to this temperature, by taking the number of seconds found in the preceding example, we have

$$\text{Log. of } 394''\cdot5 = 2\cdot5960470$$
$$\text{add } - 1\cdot3821650$$
$$\text{Required refraction} = 95''\cdot107 = 1\cdot9782120$$
$$\text{Refract. at med. temper.} = 99\cdot167$$
$$\text{Numb. in the Tab. Differ.} = 4''\cdot06 = 4'' \text{ very nearly.}$$

TABLE VII.

Corrections of Refraction relative to Atmospheric Pressure.

The refractions of Table V. are calculated for the medium pressure of the atmosphere, or 29·92 inches of the mercury in the barometer, and therefore require correction when the pressure is different from this, and great accuracy is requisite.

Now, as the refracting power of the atmosphere is proportional to its density, and its density as its pressure, it follows that the refracting power is directly as the pressure: therefore if h denote the height of the mercury in the barometer, the refracting power of the atmosphere will vary as $\frac{h}{29\cdot 92}$: hence is derived this

RULE.—*Multiply the mean refraction by this ratio, and the product will be the refraction answering to the given pressure. The difference between this and the mean refraction is the correction required.*

Example.—Required the correction of the medium refraction on account of pressure, when the height of the barometer is 29·1 inches, and the altitude of the heavenly body 30°.

Here the medium refraction is 99″, which being multiplied by $\frac{29\cdot 1}{29\cdot 92}$, gives 96″ nearly for the refraction at the given pressure 29·1 inches; and 99″ − 96″ = 3″, the required correction in the Table.

Remark.—When it is thought necessary to correct the medium refractions of Table V, both the corrections contained in this and the preceding table must be used; for the density of the atmosphere is in the direct ratio of its pressure and the inverse ratio of its temperature, and consequently in the compound ratio of the two. It is seldom necessary to make use of these corrections for *small* variations from the mean pressure and temperature corresponding to the refractions of Table V, when both these variations are either in excess or defect; for then, the one being additive and the other subtractive, the effective correction is only their difference, which is generally very small and frequently nothing. But when the one variation is in excess and the other in defect, the corrections are both additive or both subtractive, and the real correction is their sum. For example, if the thermometer were at the freezing point, and the barometer at 30·6 inches, the total correction at 10° of altitude would be 17″ + 8″ = 25″ additive; and if the barometer were at 29·1 inches, and Fahrenheit's thermometer at 75°·3, the whole correction at the same altitude would be 9″ + 11″ = 20″, subtractive.

TABLE VIII.

Parallax of the Moon less Refraction.

The moon being much the nearest of the heavenly bodies, and subject to considerable variation in her distance, her parallax is not only the greatest, but also varies with respect to both time and place. The variations depending upon the latter are given in Table III; and with respect to the former, astronomers prove that the sine of the moon's *horizontal parallax* is equal to the ratio between the radius of the earth and the distance between the centres of the earth and moon at any given time; or by adopting the initial of these words only, sin. $P = \frac{r}{d}$, which, according to Delambre, is $\frac{1635\cdot5}{98650} = \cdot0165788 =$ sin. 57′, for the mean distance of the moon from the earth; the extremes of the horizontal parallax being about 53′ and 61′. Then, if p denote the parallax at any altitude a, since this varies as the cosine of a, we easily obtain the following formula,

$$\sin. p = \sin. P \cos. a;$$

which converted into words gives this easy

RULE.—*Add the log. sine of the horizontal parallax and the log. cosine of the moon's altitude together, omitting* 10 *in the index, and the sum will be the sine of the parallax corresponding to that altitude.*

Example.—Required the moon's parallax at 30° of altitude, the horizontal parallax being 55′.

Log. sine 55′ = 8·2040703
Log. cos. 30° = 9·9375306
Parallax required 47′ 38″ = 8·1416009
Subtract refraction 1 39
Parallax—Refraction, 45′ 59″ of the Table.

The right hand page of this table also contains the proportional parts for the odd minutes of altitude, and the seconds of the horizontal parallax; by means of which the whole of the required parallax may be obtained by inspection. Thus, the first

column entitled proportional parts contains those parts corresponding to 0, 10, 20, 30, 40, and 50 seconds of the horizontal parallax; the second column contains those answering to, 1, 11, 21, 31, 41 and 51 seconds; and the third column, those for 2, 12, 22, 32, &c. The last two columns of the page contain the odd minutes of the altitude, from 1 to 9, with their corresponding proportional parts, and the proper sign at the top of the column. The use of these is evident by inspection.

TABLE IX.

Change in Altitude during the last Minute which precedes, and the first that follows, the Sun's Passage over the Meridian.

The altitude of the sun varies at every instant from his rising to his setting, increasing until he arrives at the meridian and then decreasing after he has passed it. But the variation in altitude is not uniform, owing to the different degrees of obliquity of the sun's path and the vertical circle. This change of altitude for any given time must therefore be found by calculating his zenith distances at the beginning and end of that time, and subtracting the one from the other. This altitude and its variations, however, are the same at equal intervals before and after the sun's passage over the meridian, and consequently the same calculations will answer for both the ascending and descending change. *M. Delambre*, in his "Leçons élémentaires d'Astronomie," page 207, has given the following formula for finding the zenith distance of the sun at any given time: viz.

$$\text{cos. ZA} = \text{cos. PA} \cdot \text{cos. PZ} + \text{sin. PA} \cdot \text{sin. PZ} \cdot \text{cos. P};$$

in which ZA = the zenith distance; PA = the polar distance, equal to 90 ∓ the declination, according as its denomination is the same with or different from that of the latitude; PZ = the distance between the pole and the zenith = the complement of the latitude; and P = the horary angle, in this case = 15′ of a degree. This formula therefore furnishes the following

RULE.—1st. *Add the log. cosines of 90 ∓ declination and of the complement of the latitude together, subtract 20 from the index of their sum, and find the natural number answering to the remainder.*

2d. *Add together the log. sines of the same quantities and the log. cosine of 15', subtract 30 from the index, and find the natural number corresponding to the remainder.*

3d. *Add these two natural numbers together, take the logarithm of the sum, and increase the index by 10, which will give the log. cosine of* ZA, *the zenith distance, at one minute of time before or after the sun's passage over the meridian.*

When the sun is on the meridian, the horary angle P = o, the cosine of which is equal 1, and then the zenith distance is equal to the difference of the latitude and declination when they are of the same name, or to their sum when of a different denomination. Therefore the zenith distance obtained by the calculation taken from this sum or difference will give the change in altitude during the last minute which precedes, or the first which follows, the sun's passage over the meridian.

Example.—Required the increase or decrease in the sun's altitude during the last minute before, or the first after, his passage over the meridian, the latitude being 60° and the declination 18°, both of the same denomination.

Log. cos. 72° = 9·4899824	Log. sin. 72° = 9·9782063
Log. cos. 30 = 9·9375306	Log. sin. 30 = 9·6989700
— 1·4275130	Log. cos. 15' = 9·9999959
	— 1·6771722

Nat. Numbers { ·2676165, ·4755238

Sum. ·7431403 Log. + 10 = 9·8710708

Correspond. zen. distance = 42° 0' 1''·4

Subtract 60° — 18° = 42

Change in alt. required, as in the table 1''·4

TABLE X.

Multipliers of the Numbers contained in Table IX.

This table depends upon the approximative principle, that the change in altitude during a short time before and after the sun passes the meridian, is proportional to the square of the time

included between the moment of observation and the instant of that passage; and the numbers it contains are therefore found by squaring this time expressed in minutes and decimals. This approximation is susceptible of being extended to about 8 minutes of time, or 2 degrees of space, before and after the sun's passage. If it were required to find the number in the table answering to 4′ 42″, either before or after noon, it is equal to $(4' 42'')^2 = (4'\cdot7)^2 = 22\cdot09$, or 22·1 nearly, as in the table.

TABLE XI.

Numbers for finding the Corrections of the Longitudes obtained by Marine Chronometers.

To obtain as near an approximation to the truth as possible, the gain or loss of the chronometer by which the difference of longitude is ascertained, is at first supposed to be nothing, and to increase uniformly, and therefore the gain on any given day from the commencement will be equal to the sum of the gains on all the preceding days, or to the sum of an arithmetical progression, having one for the first term, one for the common difference, and the given time in days for the number of terms: that is, the sum of the series of consecutive numbers $1+2+3+4+5+$&c. Now as the number of units in the last term of this series is always equal to the number of terms, let this term be denoted by n, and the following simple formula will give the number in the table answering to the number of days expressed by n: viz. $\frac{1}{2}\,n\,(n+1)$.

Example.—Required the number in the table answering to 57 days.

Here $n = 57$, and by substitution the formula becomes

$$\frac{57}{2}(57+1) = 57 \times 29 = 1653, \text{ the number required.}$$

TABLES XII. and XIII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

The principles upon which these tables are constructed are

investigated in Note VII, in the preceding pages; and the formula from which they are computed is

$$\text{versed sin. A} = \frac{\cos. (L \sim H)}{\cos. L . \cos. H} \mp \frac{\sin. D}{\cos. L . \cos. H};$$

where A denotes the azimuth, L the latitude, H the altitude, and D the declination of the sun. The upper sign is to be used when the latitude and declination are of the same denomination, and the lower when they are different. The left hand page of Table XII. contains the first term of this formula; and is to be entered with the latitude L and altitude H. The numbers in this table are therefore calculated by the following

Rule.—*Add the complement log. cosines of the latitude and altitude to the log. cosine of their difference, subtract 10 from the index of the sum, and the remainder will be the logarithm of the required number in the left hand page.*

And for the numbers in the right hand page, of the same table, entitled argument; *Add the two complement log. cosines of the latitude and altitude together, and their sum will be the logarithm of the required number.*

Example.—Let it be required to calculate the numbers in the table answering to 54° of latitude and 42° of altitude, when both the latitude and declination are of the same denomination.

Comp. log. cos. 54° =	0·2307813	0·3597080 sum.
Comp. log. cos. 42 =	0·1289267	Nat. numb. 2·29.
Log. cos. 12 =	9·9904044	
First term, nat. numb. 2·24 =	0·3501124	

Table XIII. contains the second member of the same formula, and is to be entered with the declination and the argument taken from the right hand page of Table XII; and therefore the numbers are readily calculated by the following

Rule.—*Add the complements of the log. cosines of the latitude and alt. add to the log. sine of the declination, diminishing the index by 10, and the remainder will be the logarithm of the required number.*

Example.—Calculate the number in Table XIII. when the declination is 20° North, and the latitude and altitude the same as in the preceding example.

Comp. log. cos.	54° =	0·2307813
Comp. log. cos.	42° =	0·1289207
Log. sin. decl.	20° =	9·5340517
Nat. numb. required ·783		1·8937537

TABLE XIV.

Azimuth corresponding to the Way made in Latitude.

The numbers in this table are the versed sines obtained from the preceding formula and their corresponding azimuthal arcs. The multipliers in the table are the versed sines, and may either be immediately calculated from the formula, as above, or found in the Tables XII and XIII, as directed in art. 40; and then the corresponding arc found in a table of natural sines.

Example.—Required the azimuth, when the given quantities are the same as in the preceding example.

The first term corresponding to these numbers has been found = 2·24, and the second = ·783; and therefore (art. 40) (2 + ·783) − 2·24 = ·543, the versed sine of the azimuth, the arc corresponding to which is $62^{\circ}\ 48'$, the number in the table very nearly; for 62° answers to the multiplier ·53 and 60° to ·55.

TABLE XV.

Altitude of the Sun when he passes the Prime Vertical.

Astronomers prove that when the sun passes the prime vertical, the sine of his altitude is equal to the sine of his declination divided by the sine of the latitude of the place of observation; the numbers in this table may therefore be easily calculated by the following simple formula, in which the respective words are denoted by their initials, viz.

$$\text{sin. A} = \frac{\text{sin. D}}{\text{sin. L}}$$

That is—*Add the complement of the log. sine of the latitude to the log. sine of the declination, and the sum will be the log. sine of the altitude.*

Example.—Required the sun's altitude when he passes the prime vertical in latitude 52° North, and his declination is 16° North.

Comp. log. sine 52° = 0·1034679
Log. sine 16 = 9·4403381
Altitude req. 20° 29′ = sine 9·5438060

TABLE XVI.

Right Ascensions and Declinations of 36 of the principal fixed Stars for the 1st of January 1815, with their annual Variations.

Astronomers generally obtain the right ascensions and declinations of the fixed stars by observation, and calculate their other elements from these. The first column of this table contains the names of the stars with their characters and magnitudes annexed; and the annual variations contained in the third column are to be added to the right ascensions of the second column for every year. Thus the right ascension for any time subsequent to the date of the table will be obtained by multiplying the annual variation by the years and parts between that date and the given time, and adding the product to the right ascensions in the table; and for any time prior to the date of the table, by subtracting this product from the tabular right ascensions.

The annual variations in the last column are also to be multiplied in the same manner, and added to the corresponding declinations in the preceding column, or subtracted from them, according as the sign is + or −; and the result will be the required declination answering to the given time.

Example.—Required the right ascension and declination of the star *Rigel* for the 1st of July, 1818.

Rt. ascen. 1 Jan. 1815 = 5h 55′ 38″·99
Variation = 2″·876 × 3·5 = + 10·07
Right. ascen. req. . . 5h 55′ 49″·06

Decl. 1 Jan. 1815 = 8° 26′ 43″·60 s.
Variation 4″·92 × 3·5 = − 17·22
Decl. required. 8° 26′ 26″·38 s.

TABLE XVII.

Containing the Logarithms of Numbers, with their Arithmetical Complements, from 1 to 5500.

This table differs from those in common use, only in having the arithmetical complements of the logarithms placed in the same line with the logarithms themselves; and consequently does not require any particular explanation. It may be observed, however, that the index to any of the complements, though not inserted in the table, is always equal to the difference between 10 and the number of places of whole numbers in the natural number corresponding to the complement; except when the number is 10, 100, 1000, &c. when it is the difference between 11 and that number. The advantage of using the complements is, that in any proportion performed by logarithms, instead of adding the second and third terms together, and subtracting the first from their sum, the three terms are added together, and 10 is omitted in the index of the sum, which is done mentally, and which therefore reduces the whole to a single operation of addition; as in the subsequent example.

One of the principal uses of common logarithms in the calculations of Nautical Astronomy, is in finding the time answering to the true calculated distance between the moon and the sun or a star. This distance is given in the Nautical Almanac for every 3 hours; and the distance for any intermediate time, or the time for any intermediate distance, is found by proportion. Thus, if the distance were given and the corresponding time required, take the difference between the next greater and next less distances in the Nautical Almanac and also between the given distance and the nearest of these: then the time corresponding to this last difference may readily be found by proportion, or by adding the logarithms of 3 hours = 10800 seconds, and of the less difference to the complement logarithm of the greater difference, omitting 10 in the index; and the natural number answering to the sum will be the time, in seconds, corresponding to the less difference,

and which must be added to or subtracted from the time corresponding to the nearest distance given in the Nautical Almanac, in order to obtain the time required.

Example.—Suppose the distance between the centres of the sun and moon on the evening of the 8th of August 1814, was 91° 54′, what was the exact time of the observation?

Distance at 6 hours P. M. = 92° 35′ 27″
Distance at 9 hours = 91 0 14
Difference in 3 hours = 1° 35′ 13″ = 95′·2 nearly.

Distance at 6 hours 92° 35′ 27″
Given distance 91 54 0
Difference 0° 41′ 27″ = 41′·45

Comp. log. 95′·2 = 8·0213631
Log. of 41·45 = 1·6175245
Log. of 3 ho. = 10800″ = 4·0334238
Corresp. time = 4702″·3 = 3·6723114 Sum, rejecting 10 in the index.

Therefore, to the nearest time = 6^h
Add 4702″·3 . . = 1 18′ 22″·3
Time required . . 7^h 18′ 22″·3

TABLE XVIII.

Containing the logarithm Sines and Cosines, with their Complements and Differences answering to every 10″; *also the logarithm Tangents and Cotangents, with their Differences corresponding to the same Arc of* 10″.

This table is different from those in common use, and will be found more convenient, as the complements of the logarithm sines and cosines can be taken from it by inspection in the same manner as the sines and cosines themselves. The differences for 10″ instead of 1′ or 60″ will also be found convenient, by avoiding the proportion in finding the logarithm answering to any number of seconds. The figures on the right hand of the differences of the cosines of small arcs and the sines of larger ones,

and separated from the rest by points, are to be considered as decimals with respect to the other figures. Thus, if it were required to find the log. sine and cosine answering to any number of degrees, minutes, and seconds, the corresponding logarithm difference for 10″ must be multiplied by the tens and units in the seconds separately, and the right hand figure of the last product omitted, carrying one, when it exceeds 5, and these two products added to the log. sine of the degrees and minutes, or subtracted from the cosine.

Example.—Required the logarithm sine and cosine of 5° 15′ 37″.

Log. sine of 5° 15′	=	8·9614288
Log. 30″ = 2288 × 3	=	6864
Log. 7 = 2288 × 7	=	1602·6
Log. sin. 5° 15′ 37″	=	8·9622755

Log. cosine 5° 15′	=	9·9981743
Log. 30″ = 19·5 × 3	=	58·5
Log. 7 = 19·5 × 7	=	13·65
Log. cos. 5° 15′ 37″	=	9·9981671

This operation of adding the two products answering to the tens and units of the seconds together and subtracting their sum from the log. cosine of the degrees and minutes may be avoided, and the whole operation performed by addition, in the same manner as for the sine, by taking the log. cosine of the next greater minute, and also the number of seconds from 60, which may be done mentally, and then adding the log. of the remaining seconds to the log. cosine of the next greater degree and minute instead of subtracting it from the next less. Thus, resuming the latter part of the preceding example, viz. to find the cosine of 5° 15′ 37″, since 60″ − 37″ = 23″, we have

Log. cosine of 5° 16′	=	9·9981626
Log. of 20″ = 19·5 × 2	=	39
Log. of 3 = 19·5 × 3	=	5·85
Log. cosine of 5° 15′ 37″	=	9·9981671 as before.

The same observations are equally applicable to the tangent and cotangent as to the sine and cosine.

The operations for finding the complements of the sines and cosines, answering to any number of seconds, are the reverse of those for the sines and cosines themselves; that is, the logarithm corresponding to the given number of seconds must be subtracted for the complement of the sine, and added for the complement of the cosine: or the subtraction may be avoided, as shown above, by taking the complement for the next greater minute and the given number of seconds from 60, and adding the corresponding logarithm. This will appear more clearly from the following:

Example.—Suppose the two sides of a spherical triangle to be 70° 35′ and 41° 23′, and the angle opposite the former 130° 4′ 28″; required the angle opposite the latter side.

	Comp. log. sine	70° 35′	= 0·0254303
	Log. sine	41 23	= 9·8202630
Log. sine 130° 4′ 28″ or 49° 55′ 32″ =		49 55	= 9·8887232
		30	= 531
		2	= 35
	Required angle =	32° 51′ 37″	= sin. 9·7344731

Note. The logarithm secant and cosecant, though not inserted in this table, may easily be found when required; viz. the *secant*, by annexing the difference between the index of the cosine and 19, as an index, to the decimal part of the complement cosine; and the *cosecant*, by annexing the difference between the index of the sine and 19, in the same manner, to the decimal part of its complement. The secant and cosecant, however, are not required by the preceding rules.

TABLES

FOR FACILITATING THE CALCULATIONS

NAUTICAL ASTRONOMY.

TABLE I.

Depression of the Horizon.

Height of the eye in feet.	Depression.	Difference.	Distance seen in miles and decimals.	Height of the eye in feet.	Depression.	Difference.	Distance seen in miles and decimals.
1	0′ 59″	24″	1·2	31	5′ 28″	5″	6·8
2	1 23	19	1·7	32	5 33	5	6·9
3	1 42	16	2·1	33	5 38	5	7·0
4	1 58	14	2·4	34	5 43	5	7·1
5	2 12	12	2·7	35	5 48	5	7·2
6	2 24	11	3·0	36	5 53	5	7·3
7	2 35	11	3·2	37	5 58	5	7·4
8	2 46	10	3·4	38	6 3	5	7·5
9	2 56	10	3·7	39	6 8	5	7·6
10	3 6	9	3·9	40	6 13	14	7·7
11	3 15	9	4·1	43	6 27	13	8·0
12	3 24	8	4·3	46	6 39	13	8·3
13	3 32	8	4·4	49	6 52	12	8·6
14	3 40	8	4·6	52	7 4	12	8·8
15	3 48	7	4·7	55	7 16	12	9·1
16	3 55	7	4·9	58	7 28	11	9·3
17	4 2	7	5·0	61	7 39	11	9·6
18	4 9	7	5·2	64	7 50	11	9·8
19	4 16	7	5·4	67	8 1	11	10·0
20	4 23	7	5·5	70	8 12	10	10·2
21	4 30	6	5·6	73	8 22	10	10·3
22	4 36	6	5·7	76	8 32	10	10·5
23	4 42	6	5·9	79	8 42	10	10·9
24	4 48	6	6·0	82	8 52	10	11·1
25	4 54	6	6·1	85	9 2	10	11·3
26	5 0	6	6·2	88	9 12	9	11·5
27	5 6	6	6·4	91	9 21	9	11·7
28	5 12	5	6·5	93	9 30	9	11·9
29	5 17	5	6·6	97	9 39	9	12·1
30	5 23	5	6·7	100	9 48	[illegible]	12·2

TABLE II.

Augmentation of the Moon's Semidiameter.

Apparent altitude.	Horizontal semidiameter.		
	14′ 30″	15′ 30″	16′ 30″
0°	0″	0″	0″
4	1	1	1
8	2	2	2
12	3	3	4
16	4	4	5
20	5	5	6
25	6	7	7
30	7	8	9
35	8	9	10
40	9	10	11
45	10	11	12
55	11	13	14
65	12	14	16
75	13	15	17
90	14	16	18

TABLE III.

Diminution of the Equatorial Parallax, at different Latitudes.

Latitude.	Equatorial parallax.	
	53′	61′
0°	0″	0″
20	1	1
25	2	2
30	3	3
35	4	4
40	4	5
45	5	6
50	6	7
55	7	8
60	8	9
65	9	10
75	10	11

TABLE IV.

Errors from the Surfaces of the large Mirror when they make with each other an Angle of 1′.

Observed angles.	Observation to the right.	Observation to the left.	Cross observations.
0°	0″	0″	0″
10	2	1	2
20	6	2	4
30	10	1	6
40	16	0	8
45	19	1	9
50	23	2	11
55	28	4	12
60	33	6	14
65	38	8	15
70	47	10	18
75	55	13	21
80	1′ 4	16	24
85	1 15	19	28
90	1 28	23	32
95	1 43	28	37
100	2 1	33	43
105	2 23	38	53
110	2 50	47	1′ 2
115	3 23	55	1 12
120	4 5	1′ 4	1 31
125	5 0	1 15	1 53
130	5 58	1 28	2 15

TABLE V.

Refraction for 29·92 Inches of the Barometer, and 57°·2 of Fahrenheit's Thermometer.

Apparent altitude.	Refraction less parallax of the ☉.	Refraction of the stars.	Differences.	Apparent altitude.	Refraction less parallax of the ☉.	Refraction of the stars.	Differences.
0° 0′	33′ 7″	33′ 16″	110″	6° 0′	8′ 13″	8′ [illegible]	11″
10	31 17	31 25	103	10	8 2	8 [illegible]	11
20	29 33	29 42	96	20	7 51	7 [illegible]	11
30	27 57	28 6	88	30	7 40	7 48	11
40	26 29	26 38	82	40	7 29	7 38	10
50	25 7	25 15	76	50	7 19	7 28	10
1 0	23 50	23 59	70	7 0	7 9	7 [illegible]	9
10	22 40	22 49	65	10	7 [illegible]	7 [illegible]	9
20	21 [illegible]	21 44	61	20	6 51	7 [illegible]	9
30	20 [illegible]	20 43	56	30	6 43	6 [illegible]	8
40	19 38	19 47	53	40	6 35	6 4[illegible]	[illegible]
50	18 [illegible]	18 54	[illegible]	50	6 27	6 36	7
2 0	17 57	18 6	[illegible]	8 0	6 20	6 28	7
10	17 12	17 20	[illegible]	10	6 13	6 21	7
20	16 29	16 38	39	20	6 5	6 14	7
30	15 50	15 59	37	30	5 58	6 7	6
40	15 13	15 22	35	40	5 52	6 1	6
50	14 39	14 47	32	50	5 46	5 54	6
3 0	14 [illegible]	14 15	30	9 0	5 39	5 48	6
10	13 36	13 45	29	10	5 33	5 42	6
20	13 7	13 16	27	20	5 28	5 36	6
30	12 41	12 49	25	30	5 22	5 31	5
40	12 15	12 24	[illegible]	40	5 17	5 25	5
50	11 51	12 0	22	50	5 12	5 20	5
4 0	11 29	11 38	22	10 0	5 6	5 15	28
10	11 7	11 16	20	11 0	4 39	4 47	23
20	10 47	10 56	19	12 0	4 15	4 24	[illegible]
30	10 28	10 37	18	13 0	3 55	4 4	[illegible]
40	10 10	10 19	17	14 0	3 38	3 46	[illegible]
50	9 53	10 2	16	15 0	3 23	3 3[illegible]	14
5 0	9 37	9 45	15	16 0	3 9	3 18	12
10	9 21	9 30	15	17 0	2 57	3 6	11
20	9 6	9 15	14	18 0	2 47	2 55	10
30	8 52	9 1	14	19 0	2 37	2 45	9
40	8 38	8 47	13	20 0	2 28	2 36	8
50	8 26	8 34	12	21 0	2 20	2 28	
6 0	8 13	8 22					

TABLE V.

[illegible] for 29.92 Inches of the Barometer, and 57[illegible] of Fahrenheit's Thermometer.

Apparent altitude.	Refraction less parallax of the ☉.	Refraction of the stars.	Differences.
21°	2′ 20″	2′ 28″	7″
22	2 13	2 21	7
23	2 6	2 14	6
24	2 0	2 8	5
25	1 55	2 3	6
26	1 49	1 57	
27	1 44	1 52	5
28	1 40	1 48	4
29	1 36	1 43	4
30	1 32	1 39	4
31	1 28	1 [illegible]	4
32	1 24	1 32	4
33	1 21	1 [illegible]	3
34	1 18	1 25	3
35	1 15	1 22	3
36	1 12	1 19	3
37	1 9	1 16	3
38	1 6	1 13	3
39	1 [illegible]	1 11	2
40	1 2	1 8	2
41	0 59	1 6	2
42	0 57	1 4	2
43	0 55	1 2	2
44	0 53	0 59	2
45	0 51	0 57	2
46	0 49	0 55	2
47	0 48	0 54	1
48	0 46	0 52	2
49	0 44	0 50	2
50	0 43	0 48	1
51	0 41	0 46	2
52	0 39	0 45	1
53	0 38	0 43	1
54	0 37	0 42	1
55	0 35	0 40	2
56	0 34	0 39	1

Apparent altitude.	Refraction less parallax of the ☉.	Refraction of the stars.	Differences.
56°	0′ 34″	0′ 39″	1″
57	0 33	0 37	1
58	0 31	0 36	1
59	0 30	0 35	1
60	0 29	0 [illegible]	1
61	0 28	[illegible]	
62	0 26	0 31	1
63	0 25	0 29	1
64	0 24	0 [illegible]	1
65	0 23	0 [illegible]	1
66	0 22	0 25	1
67	0 21	0 24	1
68	0 20	0 23	1
69	0 19	0 22	1
70	0 18	0 21	1
71	0 17	0 20	1
72	0 16	0 19	1
73	0 15	0 18	1
74	0 14	0 17	1
75	0 13	0 15	1
76	0 12	0 14	1
77	0 11	0 13	1
78	0 10	0 12	1
79	0 10	0 11	1
80	0 9	0 10	1
81	0 8	0 9	1
82	0 7	0 8	1
83	0 6	0 7	1
84	0 5	0 6	1
85	0 4	0 5	1
86	0 3	0 4	1
87	0 3	0 3	1
88	0 2	0 2	1
89	0 1	0 1	1
90	[illegible] 0	0 0	

TABLE VI.

Corrections of Refraction relative to Temperature.

The refractions of TABLE V answer to 57 2 of Fahrenheit's thermometer. Cold increases refraction.

Add the following numbers to the refractions of TABLE V;

Subtract them from the numbers of TABLE VIII, or from the parallax of the moon less refraction.

Fahrenheit's thermometer.

Apparent altitude	26°	29°	32°	3[illegible]°	38°	41°	44°	47°	50°	5[illegible]°	56	57°·2
5°	10	36	32	29	25″	21	17	1[illegible]′	9	6′	[illegible]	0′
5½	38	34	30	27	2[illegible]	19	1[illegible]	11	8	4	1	0
6	35	[illegible]1	28	24	21	1[illegible]	1[illegible]	11	8	4	1	0
7	32	26	[illegible]	21	18	15	1[illegible]	9	7	3	1	0
8	28	25	22	19	16	1[illegible]	11	8	6	3	1	0
9	24	22	19	16	15	12	10	8	5	3	1	0
10	22	20	17	15	12	11	9	7	5	2	0	0
12	19	17	15	12	11	9	7	[illegible]	4	2	0	0
14	16	14	13	11	10	8	[illegible]	[illegible]	[illegible]	2	0	0
16	15	1[illegible]	11	9	8	7	5	4		2	0	0
18	13	11	10	8	7	6	5	4	3	1	0	0
20	11	10	9	7	6	[illegible]	5	4	3	1	0	0
25	9	[illegible]	7	6	[illegible]	[illegible]	4	[illegible]	2	1	0	0
30	7	6	6	5	4		3	[illegible]	2	1	0	0
40	5	4	4	3	3	2	[illegible]	[illegible]	1	1	0	0
50	4	3	[illegible]	2	2	2	1	1	1	0	0	0
60	3	[illegible]		2	1	1	1	1	0	0	0	0
70	2	1	1	1	1	1	1	0	0	0	0	0
80	1	1	1	1	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0

TABLE VI.

Corrections of Refraction relative to Temperature.

The refractions of Table V answer to 57°·2 of Fahrenheit's thermometer. Heat diminishes refraction.

Subtract the following numbers from the refractions of Table V;

Add them to the numbers of Table VIII, or to the parallax of the moon less refraction.

Fahrenheit's thermometer.

Apparent altitude.	57°·2	60°	63°	66°	69°	72°	75°	78°	81°	84°	87°	90°
5°	0″	3″	7″	11″	14″	17″	21″	24″	27″	31″	34″	37″
5½	0	3	6	10	13	16	20	22	25	29	32	35
6	0	3	6	9	12	15	18	21	24	26	29	32
7	0	2	5	8	11	13	16	18	21	23	26	28
8	0	2	5	7	10	12	14	16	19	21	23	25
9	0	2	4	6	8	10	12	14	16	18	20	22
10	0	2	4	6	8	9	11	13	15	17	19	21
12	0	2	3	5	7	[illegible]	10	11	12	14	16	17
14	0	2	3	4	6	7	8	10	11	12	13	15
16	0	1	2	3	5	6	7	9	10	11	12	13
18	0	1	2	3	4	5	6	8	8	9	10	11
20	0	1	2	2	3	5	6	7	8	8	9	10
25	0	1	2	2	3	4	5	5	6	6	7	8
30	0	1	2	2	3	3	4	4	5	5	6	7
40	0	1	1	2	2	2	3	3	3	3	4	5
50	0	0	1	1	1	1	2	2	2	2	3	3
60	0	0	0	1	1	1	1	1	2	2	2	2
70	0	0	0	0	1	1	1	1	1	1	1	1
80	0	0	0	0	0	0	0	0	1	1	1	1
90	0	0	0	0	0	0	0	0	0	0	0	0

TABLE VII.

Corrections of Refraction, relative to Atmospheric Pressure.

The refractions of TABLE V are those which take place, when the atmosphere sustains a column of mercury of 29·92 inches.

Refraction increases with the pressure of the atmosphere.

Add the following numbers to the refractions of TABLE V.

Subtract them from the numbers of TABLE VIII, or the parallax of the moon less refraction.

Height of the barometer in inches.

Apparent altitude.	in. 31·22	in. 31·12	in. 30·92	in. 30·72	in. 30·52	in. 30.32	in. 30·12	in. 29·92
5°	27″	23″	19″	16″	12″	8″	4″	0″
5½	25	22	18	14	11	7	4	0
6	24	20	17	13	10	7	3	0
7	21	18	15	12	9	6	3	0
8	18	16	13	10	[illegible]	5	3	0
9	16	14	12	9	7	5	2	0
10	15	12	11	8	6	4	2	0
12	12	11	9	7	5	4	2	0
14	10	9	8	6	5	3	2	0
16	9	8	7	5	4	2	1	0
18	8	7	6	5	4	2	1	0
20	7	6	5	4	3	2	1	0
25	6	5	4	3	3	2	1	0
30	5	4	3	3	2	1	1	0
40	3	3	2	2	1	1	1	0
50	2	2	2	1	1	1	0	0
60	2	1	1	1	1	1	0	0
70	1	1	1	1	0	0	0	0
80	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0

TABLE VII.

Corrections of Refraction, relative to Atmospheric Pressure.

The refractions of TABLE V are those which take place when the atmosphere sustains a column of mercury of 29·92 inches.

Refraction diminishes as the pressure of the atmosphere decreases.

Subtract the following numbers from the refractions of TABLE V;

Add them to the numbers of TABLE VIII, or the parallax of the moon less refraction.

Height of the barometer in inches.

Apparent altitude.	in. 29·92	in. 29·72	in. 29·52	in. 29·32	in. 29·12	in. 28·92	in. 28·72	in. 28·52
5°	0″	4″	8″	12″	16″	20″	24″	27″
5½	0	4	7	11	15	18	22	25
6	0	3	[illegible]	10	14	[illegible]	20	24
7	0	3	6	9	12	15	18	21
8	0	3	5	8	11	14	16	18
9	0	2	5	7	10	12	14	16
10	0	2	4	6	9	11	13	15
12	0	2	4	5	7	9	11	[illegible]
14	0	2	3	5	6	8	9	11
16	0	1	3	4	5	7	8	9
18	0	1	2	4	5	6	7	8
20	0	1	2	3	4	5	6	7
25	0	1	2	2	3	4	5	[illegible]
30	0	1	1	2	3	[illegible]	4	5
40	0	0	1	1	2	[illegible]	3	3
50	0	0	1	1	1	2	2	2
60	0	0	0	1	1	1	1	2
70	0	0	0	0	1	1	1	1
80	0	0	0	0	0	0	0	1
90	0	0	0	0	0	0	0	0

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53′		54′		55′		56′		57′		58′		59′	
0°	0′	19′	44″	20′	44″	21′	44″	22′	44″	23′	44″	24′	44″	25′	44″
	10	21	36	22	36	23	36	24	36	25	36	26	36	27	36
	20	23	18	24	18	25	18	26	18	27	18	28	18	29	18
	30	24	54	25	54	26	54	27	54	28	54	29	54	30	54
	40	26	22	27	22	28	22	29	22	30	22	31	22	32	22
	50	27	45	28	45	29	45	30	45	31	45	32	45	33	45
1	0	29	1	30	1	31	1	32	1	33	1	34	1	35	1
	10	30	9	31	9	32	9	33	9	34	9	35	9	36	9
	20	31	16	32	16	33	16	34	16	35	16	36	16	37	16
	30	32	16	33	16	34	16	35	16	36	16	37	16	38	16
	40	33	12	34	12	35	12	36	12	37	12	38	12	39	12
	50	34	5	35	5	36	5	37	5	38	5	39	[illegible]	40	5
2	0	34	52	35	52	36	52	37	52	38	52	39	52	40	52
	10	35	38	36	38	37	38	38	38	39	38	40	37	41	37
	20	36	19	37	19	38	19	39	19	40	19	41	19	42	19
	30	36	58	37	58	38	58	39	57	40	57	41	57	42	57
	40	37	35	38	35	39	35	40	35	41	34	42	34	43	34
	50	38	9	39	9	40	9	41	9	42	9	43	9	44	9
3	0	38	41	39	41	40	40	41	40	42	40	43	40	44	40
	10	39	10	40	10	41	10	42	10	43	10	44	9	45	9
	20	39	38	40	38	41	38	42	38	43	38	44	38	45	38
	30	40	5	41	5	42	[illegible]	43	4	44	4	45	4	46	4
	40	40	30	41	30	42	29	43	29	44	29	45	29	46	29
	50	40	53	41	53	42	53	43	53	44	53	45	53	46	52
4	0	41	14	42	14	43	14	44	14	45	14	46	13	47	13
	10	41	36	42	36	43	35	44	35	45	35	46	35	47	35
	20	41	55	42	55	43	55	44	55	45	54	46	54	47	54
	30	42	13	43	13	44	13	45	13	46	13	47	13	48	12
	40	42	30	43	30	44	30	45	30	46	30	47	30	48	29
	50	42	47	43	47	44	46	45	46	46	46	47	46	48	45
5	0	43	3	44	3	45	3	46	2	47	2	48	2	49	2
	10	43	17	44	17	45	17	46	17	47	16	48	16	49	16
	20	43	32	44	32	45	31	46	31	47	31	48	31	49	30
	30	43	44	44	44	45	44	46	44	47	44	48	43	49	43
	40	43	57	44	57	45	57	46	57	47	57	48	56	49	56
	50	44	9	45	9	46	9	47	8	48	8	49	8	50	7

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the [illegible].
60′		61′		0″	1′	2′	3′	4′	5′	6′	7′	8′	9′	
26′	[illegible]	[illegible]	44″	0″	1	2	3	4	5	6	7	8	9	
28	[illegible]	[illegible]	36	10	11	12	13	14	15	16	17	18	19	
30	[illegible]	31	18	20	21	22	23	24	25	26	27	28	29	
31	[illegible]	32	54	[illegible]	[illegible]	[illegible]	33	34	35	36	37	38	39	
33	22	34	29	[illegible]	41	[illegible]	43	44	45	46	47	48	49	
34	45	35	45	50	51	52	53	54	55	56	57	58	59	
36	1	37	1	[illegible]	1	2	3	4	5	6	7	8	9	
37	9	38	9	[illegible]	11	12	13	14	15	16	17	18	19	
38	16	39	16	20	21	22	23	24	25	26	27	28	29	
39	[illegible]	40	16	30	31	[illegible]	33	34	35	36	37	38	39	
40	[illegible]	41	12	40	41	42	43	44	45	46	47	48	49	
41	[illegible]	42	5	50	51	52	53	54	55	56	57	58	59	
41	52	42	[illegible]	0	1	2	3	4	5	6	7	8	9	
42	[illegible]	43	[illegible]	10	11	12	13	14	15	16	17	18	19	
43	19	44	19	20	21	22	23	24	25	26	27	28	29	
43	57	44	57	30	31	32	33	34	35	36	37	38	39	
44	34	45	34	40	41	42	43	44	45	46	47	48	49	
45	9	46	9	50	51	52	53	54	55	56	57	58	59	
45	40	46	40	0	1	[illegible]	3	4	5	6	7	8	9	
46	9	47	9	10	11	12	13	14	15	16	17	18	19	
46	38	47	37	20	21	22	23	24	25	26	27	28	29	
47	4	48	4	30	31	32	33	34	35	36	37	38	39	
47	29	48	29	40	41	42	43	44	45	46	47	48	49	
47	52	48	52	50	51	52	53	54	55	56	57	58	59	
48	13	[illegible]	13	0	1	2	3	4	5	6	7	8	9	
48	35	49	34	10	11	12	13	14	15	16	17	18	19	
48	54	49	54	20	21	22	23	24	25	26	27	28	29	
49	12	50	12	30	31	32	33	34	35	36	37	38	39	
49	29	50	29	40	41	42	43	44	45	46	47	48	49	
49	45	50	45	50	51	52	53	54	55	56	57	58	59	
50	1	51	1	0	1	2	3	4	5	6	7	8	9	
50	16	51	15	10	11	12	13	14	15	16	17	18	19	
50	30	51	30	20	21	22	23	24	25	26	27	28	29	
[illegible]	43	51	42	30	31	32	33	34	35	36	37	38	39	
[illegible]	56	51	55	40	41	42	43	44	[illegible]	[illegible]	47	48	49	
[illegible]	7	52	7	50	51	52	53	54	55	56	57	58	59	

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53'		54'		55'		56'		57'		58'		59'	
6°	0'	44'	21"	45'	21"	46'	20"	47'	2	48'	20"	49'	[illegible]"	50'	19"
	10	44	31	45	31	46	30	47	30	48	30	49	29	50	29
	20	44	41	45	41	46	41	47	41	48	40	49	40	50	40
	30	44	51	45	51	46	51	47	51	48	50	49	50	50	50
	40	45	0	46	0	47	0	47	59	48	59	49	58	50	58
	50	45	9	46	9	47	9	48	8	49	8	50	7	51	7
7		45	18	46	18	47	17	48	17	49	16	50	16	51	16
	10	45	26	46	26	47	26	48	25	49	25	50	24	51	24
	20	45	34	46	34	47	34	48	[illegible]	[illegible]	33	50	32	51	32
	30	45	41	46	41	47	41	48	[illegible]	49	40	50	39	51	39
	40	45	48	46	48	47	48	48	47	49	47	50	46	51	46
	50	45	54	46	54	47	54	48	53	49	53	50	52	51	51
8	0	46	1	47	1	48	0	49	0	49	59	[illegible]	[illegible]	[illegible]	58
	10	46	6	47	6	48	5	49	5	50	4	[illegible]	[illegible]	[illegible]	3
	20	46	12	47	12	48	11	49	10	50	10	51	9	52	9
	30	46	17	47	17	48	17	49	16	50	15	51	15	52	14
	40	46	23	47	23	48	22	49	21	50	21	51	20	52	19
	50	46	28	47	28	48	27	49	[illegible]	50	26	51	25	52	24
9	0	46	33	47	32	48	32	49	31	50	30	51	30	52	29
	10	46	37	47	37	48	36	49	36	50	35	51	34	52	33
	20	46	42	47	41	48	41	49	40	50	39	51	38	52	37
	30	46	46	47	45	48	44	49	43	50	42	51	41	52	40
	40	46	49	47	48	48	48	49	47	50	46	51	45	52	44
	50	46	52	47	52	48	51	49	50	50	50	51	49	52	48
10	0	46	57	47	56	48	55	49	54	50	53	51	52	52	51
	10	47	0	47	59	48	58	49	57	50	56	51	55	52	54
	20	47	3	48	2	49	1	50	0	50	59	51	58	52	57
	30	47	6	48	5	49	4	50	3	51	2	52	1	53	0
	40	47	9	48	8	49	7	50	6	51	5	52	4	53	3
	50	47	[illegible]	48	11	49	10	50	9	51	8	52	7	53	6
11	0	47	14	48	13	49	12	50	11	51	10	52	9	53	8
	10	47	17	48	16	49	15	50	14	51	12	52	11	53	10
	20	47	19	48	18	49	17	50	16	51	15	52	13	53	12
	30	47	21	48	20	49	19	50	18	51	17	52	15	53	14
	40	47	23	48	22	49	21	50	20	51	19	52	17	53	16
	50	47	25	48	24	49	23	50	22	51	20	52	19	53	18

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60′		61′		0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		+
51′	19″	52′	18″	0	1	2	3	4	5	6	7	8	9		
51	29	52	28	10	11	12	13	14	15	16	17	18	19		
51	39	52	39	20	21	22	23	24	25	26	27	28	29		
51	49	52	49	30	31	32	33	34	35	36	37	38	39		
51	58	52	57	40	41	42	43	44	45	46	47	48	49		
52	7	53	6	50	51	52	53	54	55	56	57	58	59		
52	15	53	15	0	1	2	3	4	5	6	7	8	9		
52	23	53	23	10	11	12	13	14	15	16	17	18	19		
52	31	53	31	20	21	22	23	24	25	26	27	28	29		
52	38	53	38	30	31	32	33	34	35	36	37	38	39		
52	45	53	45	40	41	42	43	44	45	46	47	48	49		
52	51	53	50	50	51	52	53	54	55	56	57	58	58		
52	57	53	[illegible]	0	1	2	3	4	5	6	7	8	9		
53	2	54	[illegible]	10	11	12	13	14	15	16	17	18	19		
53	8	54	[illegible]	20	21	22	23	24	25	26	27	28	29		
53	13	54	13	30	31	32	33	34	35	36	37	38	39		
53	18	54	18	40	41	42	48	44	45	45	46	47	48		
53	23	54	23	49	50	51	52	53	54	55	56	57	58		
53	28	54	27	0	1	[illegible]	3	4	5	6	7	8	9		
53	32	54	32	10	11	12	13	14	15	16	17	18	19		
53	37	54	36	20	21	22	23	24	25	26	27	28	29		
53	40	54	39	30	31	32	33	34	35	36	36	37	38		
53	43	54	43	39	40	41	42	43	44	45	46	47	48		
53	47	54	46	49	50	51	52	53	54	55	56	57	58		
53	50	54	49	0	1	2	3	4	5	6	7	8	9	1′	0″
53	53	54	53	10	11	12	13	11	15	16	17	18	19	2	0
53	57	54	56	20	21	22	23	24	25	26	27	28	29	3	1
53	59	54	58	29	30	31	32	33	34	35	36	37	38	4	1
54	2	55	1	39	40	41	42	43	44	45	46	47	48	5	1
54	4	55	3	49	50	51	52	53	54	55	56	57	58	6	1
														7	2
54	7	55	6	0	1	2	3	4	5	6	7	8	9	8	2
54	9	55	8	10	11	12	13	14	15	16	17	18	19	9	2
54	11	55	10	20	21	22	23	24	24	25	26	27	28		
54	13	55	12	29	30	31	32	33	34	35	36	37	38		
54	15	55	14	39	40	41	42	43	44	45	46	47	48		
54	16	55	15	49	50	51	52	53	54	55	56	57	58		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude		Horizontal parallax.													
		53′		54′		55′		56′		57′		58′		59′	
12°	0′	47′	27″	48′	25″	49′	25″	50′	23″	51′	[illegible]	52′	21″	53′	19″
	10	47	29	48	27	49	26	50	24	51	23	52	22	53	21
	20	47	30	48	29	49	28	50	26	51	25	52	23	53	22
	30	47	32	48	30	49	29	50	28	51	26	52	25	53	23
	40	47	33	48	32	49	30	50	[illegible]	51	27	52	26	53	24
	50	47	34	48	33	49	31	50	30	51	28	52	27	53	25
13	0	47	35	48	34	49	32	50	31	51	29	52	28	53	26
	10	47	36	48	35	49	33	50	[illegible]	51	30	52	28	53	27
	20	47	36	48	36	49	34	50	[illegible]	51	31	52	29	53	28
	30	47	38	48	36	49	35	50	[illegible]	51	31	52	30	53	28
	40	47	39	48	37	49	35	50	34	51	32	52	30	53	29
	50	47	39	48	38	49	36	50	34	51	32	52	31	53	29
14	0	47	40	49	38	49	36	50	35	51	33	52	31	53	29
	10	47	40	48	38	49	37	50	35	51	33	52	31	53	29
	20	47	41	48	39	49	37	50	35	51	33	52	31	53	30
	30	47	41	48	39	49	37	50	35	51	33	52	31	53	30
	40	47	41	48	39	49	37	50	35	51	33	52	31	53	30
	50	47	41	48	39	49	37	50	35	51	33	52	31	53	29
15	0	47	41	48	39	49	37	50	35	51	33	52	31	53	29
	10	47	41	48	39	49	37	50	35	51	33	52	31	53	29
	20	47	41	48	39	49	37	50	35	51	33	52	31	53	28
	30	47	41	48	39	49	37	50	34	51	32	52	30	53	28
	40	47	41	48	[illegible]	49	36	50	34	51	32	52	30	53	27
	50	47	40	48	38	49	36	50	34	51	31	52	29	53	27
16	0	47	40	48	38	49	35	50	33	51	31	52	28	53	26
	10	47	40	48	37	49	35	50	32	51	30	52	28	53	25
	20	47	39	48	36	49	34	50	32	51	29	52	27	53	24
	30	47	[illegible]	48	36	49	33	50	31	51	29	52	26	53	24
	40	47	[illegible]	[illegible]	35	49	33	50	30	51	28	52	25	53	23
	50	47	[illegible]	48	34	49	32	50	29	51	27	52	24	53	22
17	0	47	36	48	34	49	31	50	28	51	26	52	23	53	21
	10	47	35	48	33	49	30	50	27	51	25	52	22	53	19
	20	47	34	48	32	49	29	50	26	51	24	52	21	53	18
	30	47	34	48	31	49	28	50	25	51	22	52	20	53	17
	40	47	33	48	30	49	27	50	24	51	21	52	18	53	16
	50	47	31	48	29	49	26	50	23	51	20	52	16	53	14

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60'		61'		0"	1"	2"	3"	4"	5"	6"	7"	8"	9"		+
54'	18"	55'	17"	0	1	2	3	4	5	6	7	8	9	1'	0"
54	19	55	18	10	11	12	13	14	15	16	17	18	19	2	0
54	21	55	19	20	21	[illegible]	22	23	24	25	26	27	28	3	0
54	22	55	20	29	30	31	32	33	34	35	36	37	38	4	[illegible]
54	23	55	21	39	40	41	42	43	44	45	46	47	48	5	[illegible]
54	24	55	22	49	50	51	52	53	54	55	56	57	58	6	[illegible]
														7	1
														8	1
54	25	55	23	0	1	2	[illegible]	4	5	6	7	8	9	9	1
54	25	55	24	10	11	12	13	14	15	16	17	18	18		
54	26	55	24	19	20	[illegible]	22	23	24	25	26	27	28		
54	26	55	25	29	30	[illegible]	32	33	34	35	36	37	38		
54	27	55	25	39	40	[illegible]	42	43	44	45	46	47	48		
54	27	55	25	49	50	51	52	53	53	54	55	56	57		
54	27	55	[illegible]	0	1	2	3	4	5	6	7	8	9	1	0
54	[illegible]	55	[illegible]	10	11	12	13	14	15	[illegible]	16	17	18	2	0
54	[illegible]	55	26	19	20	21	22	23	24	25	26	27	28	3	0
54	28	55	[illegible]	29	30	31	32	33	34	35	36	37	38	4	0
54	28	55	26	39	40	41	42	43	44	45	46	46	47	5	0
54	27	55	25	48	49	50	51	52	53	54	55	56	57	6	0
														7	0
														8	0
54	27	55	25	0	1	2	3	4	5	6	7	8	9	9	0
54	27	55	24	10	11	12	13	14	14	15	16	17	18		
54	26	55	24	19	20	21	22	23	24	25	26	27	28		
54	26	55	24	29	30	31	32	33	34	35	36	37	38		
54	25	55	23	39	39	40	41	42	43	44	45	46	47		−
54	24	55	22	48	49	50	51	52	53	54	55	56	57		
54	24	55	21	0	1	2	3	4	5	6	7	8	9	1'	0
54	23	55	21	10	11	12	12	13	14	15	16	17	18	2	0
54	22	55	20	19	20	21	22	23	24	25	26	27	28	3	0
54	21	55	19	29	30	31	32	33	34	35	35	36	37	4	0
54	20	55	18	38	39	40	41	42	43	44	[illegible]	46	47	5	1
54	19	55	16	48	49	50	51	52	53	54	[illegible]	56	57	6	1
														7	1
														8	1
54	18	55	15	0	1	2	3	4	5	6	7	8	9	9	1
54	17	55	14	10	10	11	12	13	14	15	16	17	18		
54	15	55	13	19	20	21	22	23	24	25	26	27	28		
54	14	55	11	29	30	30	31	32	33	34	35	36	37		
54	14	55	10	38	39	40	41	42	43	44	45	46	47		
54	12	55	8	48	49	50	51	51	52	53	54	55	56		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53′		54′		55′		56′		57′		58′		59′	
18°	0″	47′	30″	48′	27″	49′	24″	50′	22″	51′	19″	52′	16″	53′	13″
	10	47	29	48	26	49	23	50	20	51	[illegible]	52	14	53	11
	20	47	28	48	25	49	22	50	19	51	16	52	13	53	10
	30	47	27	48	24	49	20	50	17	51	14	52	11	53	8
	40	47	25	48	22	49	19	50	16	51	13	52	9	53	6
	50	47	24	48	21	49	17	50	14	51	11	52	8	53	5
19	0	47	22	48	19	49	16	50	13	51	9	52	6	53	3
	10	47	21	48	18	49	14	50	11	51	8	52	4	53	1
	20	47	19	48	16	49	13	50	9	51	6	52	2	52	59
	30	47	18	48	14	49	11	50	8	51	4	52	1	52	57
	40	47	16	48	13	49	9	50	6	51	2	51	59	52	55
	50	47	14	48	11	49	7	50	4	51	0	51	57	52	53
20	0	47	13	48	9	49	5	50	2	50	58	51	55	52	51
	10	47	11	48	7	49	3	50	0	50	56	51	52	52	49
	20	47	9	48	5	49	2	49	58	50	54	51	50	52	47
	30	47	7	48	3	49	0	49	56	50	52	51	48	52	44
	40	47	5	48	1	48	57	49	54	50	50	51	46	52	42
	50	47	3	47	59	48	55	49	51	50	48	51	44	52	40
21	0	47	1	47	57	48	53	49	49	50	45	51	41	52	37
	10	46	59	47	55	48	51	49	47	50	43	51	39	52	35
	20	46	57	47	53	48	49	49	45	50	41	51	36	52	32
	30	46	55	47	51	48	46	49	42	50	38	51	34	52	30
	40	46	53	47	48	48	44	49	40	50	36	51	31	52	27
	50	46	50	47	46	48	42	49	37	50	33	51	29	52	25
22	0	46	48	47	44	48	39	49	35	50	31	51	26	52	22
	10	46	46	47	41	48	37	49	32	50	28	51	24	52	19
	20	46	43	47	39	48	34	49	30	50	25	51	21	52	16
	30	46	41	47	36	48	32	49	27	50	23	51	18	52	14
	40	46	39	47	34	48	29	49	25	50	20	51	15	52	11
	50	46	36	47	31	48	27	49	22	50	17	51	13	52	8
23	0	46	34	47	29	48	24	49	19	50	14	51	10	52	5
	10	46	31	47	26	48	21	49	17	50	12	51	7	52	2
	20	46	28	47	23	48	19	49	14	50	9	51	4	51	59
	30	46	26	47	21	48	16	49	11	50	6	51	1	51	56
	40	46	23	47	18	48	13	49	8	50	3	50	58	51	53
	50″	46	20	47	15	48	10	49	5	50	0	50	55	51	50

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60′		61′		0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	[illegible]	−
54′	10″	55′	7″	[illegible]	1	2	3	4	5	6	7	8	9	1′	0″
54	8	55	5	9	10	11	12	13	14	15	16	17	18	2	0
54	7	55	4	19	20	21	22	23	24	25	26	27	27	3	0
54	5	55	2	28	29	30	31	32	33	34	35	36	37	4	1
54	3	55	0	38	39	40	41	42	43	44	45	46	46	5	1
54	1	54	58	47	48	49	50	51	52	53	54	55	56	6	1
														7	1
54	0	54	56	0	1	2	3	4	5	6	7	8	8	8	1
53	58	54	54	9	10	11	12	13	14	15	16	17	18	9	1
53	56	54	52	19	20	[illegible]	22	23	24	24	25	26	27		
53	54	54	50	28	29	30	31	32	33	34	35	36	37		
53	52	54	48	38	39	40	41	41	42	43	44	45	46		
53	49	54	46	47	48	49	50	51	52	53	54	55	56		
53	47	54	44	0	1	2	3	4	5	6	7	8	8	1	0
53	45	54	41	9	10	11	12	13	14	15	16	17	18	2	0
53	43	54	39	19	20	21	22	22	23	24	25	26	27	3	1
53	41	54	37	28	29	30	31	32	33	34	35	36	37	4	1
53	38	54	34	37	38	39	40	41	42	43	44	45	46	5	1
53	[illegible]	54	32	47	48	49	50	51	51	52	53	54	55	6	1
														7	2
53	33	54	29	0	1	2	3	4	5	6	7	7	8	8	2
53	31	54	27	9	10	11	12	13	14	15	16	17	18	9	2
53	28	54	24	19	20	20	21	22	23	24	25	26	27		
53	26	54	21	28	29	30	31	32	33	33	34	35	36		
53	23	54	19	37	38	39	40	41	42	43	44	45	46		
53	20	54	16	47	47	48	49	50	51	52	53	54	55		
53	18	54	13	0	1	2	3	4	5	6	6	7	8		
53	15	54	10	9	10	11	12	13	14	15	16	17	18	1	0
53	12	54	7	18	19	20	21	22	23	24	25	26	27	2	1
53	9	54	4	28	29	30	30	31	32	33	34	35	36	3	1
53	6	54	1	37	38	39	40	41	42	43	[illegible]	44	45	4	1
53	3	53	58	46	47	48	49	50	51	52	[illegible]	54	55	5	1
														6	2
53	0	53	55	0	1	2	3	4	5	6	6	7	8	7	2
52	57	53	52	9	10	11	12	13	14	15	16	17	17	8	2
52	54	53	49	18	19	20	21	22	23	24	25	26	27	9	2
52	51	53	46	28	28	29	30	31	32	33	34	35	36		
52	48	53	43	37	38	39	39	40	41	42	43	44	45		
52	45	53	40	46	47	48	49	50	50	51	52	53	54		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53'		54'		55'		56'		57'		58'		59'	
24°	0'	46'	18"	47'	12"	48'	7"	49'	2"	49'	57"	50'	52"	51'	46"
	10	46	15	47	9	48	4	48	59	49	54	50	48	51	43
	20	46	12	47	7	48	1	48	56	[illegible]	51	50	45	51	40
	30	46	9	47	4	47	58	48	53	49	48	50	42	51	37
	40	46	6	47	1	47	55	48	50	49	44	50	39	51	33
	50	46	3	46	57	47	51	48	47	49	41	50	36	51	30
25	0	46	0	46	55	47	49	48	43	49	38	50	32	51	27
	10	45	57	46	52	47	46	48	40	49	35	50	29	51	23
	20	45	54	46	48	47	43	48	37	[illegible]	31	50	25	51	20
	30	45	51	46	45	47	40	48	34	49	28	50	22	51	16
	40	45	48	46	42	47	36	48	30	49	24	50	18	51	13
	50	45	45	46	39	47	33	48	27	49	21	50	15	51	9
26	0	45	42	46	36	47	30	48	24	49	17	50	11	51	5
	10	45	38	46	32	47	26	48	20	49	14	50	8	51	2
	20	45	35	46	29	47	23	[illegible]	17	49	10	50	4	50	58
	30	45	32	46	26	47	19	48	13	49	7	50	0	50	54
	40	45	29	46	22	47	16	48	9	49	3	49	57	50	50
	50	45	25	46	19	47	12	48	6	48	59	49	53	50	47
27	0	45	22	46	15	47	9	48	2	48	56	49	49	50	43
	10	45	18	46	11	47	5	47	59	48	52	49	45	50	39
	20	45	15	46	8	47	2	47	55	48	43	49	42	50	35
	30	45	12	46	5	46	58	47	51	48	44	49	38	50	31
	40	45	8	46	1	46	54	47	47	48	41	49	[illegible]	50	27
	50	45	4	45	58	46	51	47	44	48	37	49	30	50	23
28	0	45	1	45	54	46	47	47	40	48	33	49	26	50	19
	10	44	57	45	50	46	43	47	36	48	29	49	22	50	15
	20	44	54	45	46	46	39	47	32	48	25	49	18	50	11
	30	44	50	45	43	46	35	47	28	48	21	49	14	50	6
	40	44	46	45	39	46	32	47	24	48	17	49	9	50	2
	50	44	43	45	35	46	28	47	20	48	13	49	5	49	58
29	0	44	39	45	[illegible]	46	[illegible]	47	16	48	9	49	1	49	54
	10	44	35	45	27	46	20	47	12	48	5	48	57	49	49
	20	44	31	45	23	46	16	[illegible]	8	48	0	48	53	49	45
	30	44	27	45	20	[illegible]	[illegible]	47	4	47	56	48	48	49	41
	40	44	23	45	16	46	[illegible]	47	0	47	52	48	44	49	36
	50	44	19	45	11	46	[illegible]	46	56	47	48	48	40	49	32

TABLE VIII.

Parallax of the Moon less Refraction.

60′		61′		Proportional parts for the parallax.										For the altitude.	
				0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		—
52′	41″	53′	36″	0	1	2	3	4	5	5	6	7	8	1′	0′
52	38	53	33	9	10	11	12	13	14	15	15	16	17	2	1
52	35	53	28	18	19	20	21	22	23	24	25	25	26	3	1
52	31	53	26	27	28	29	30	31	32	33	34	35	35	4	1
52	28	53	22	36	37	38	39	40	41	42	43	44	45	5	2
52	24	53	19	46	46	47	48	49	50	51	52	53	54	6	2
														7	2
52	21	53	15	0	1	2	3	4	5	5	6	7	8	8	3
52	17	53	12	9	10	11	12	13	14	14	15	16	17	9	3
52	14	53	7	18	19	20	21	22	23	23	24	25	26		
52	10	53	4	27	28	29	30	31	32	32	33	34	35		
52	7	53	1	36	37	38	39	40	41	41	42	43	44		
52	3	52	57	45	46	47	48	49	50	51	51	52	53		
51	59	52	53	0	1	2	3	4	4	5	6	7	8	1	0
51	55	52	49	9	10	11	12	13	13	14	15	16	17	2	1
51	52	52	45	18	19	20	[illegible]	21	22	23	24	25	26	3	1
51	48	52	42	27	28	29	[illegible]	30	31	32	33	34	35	4	1
51	44	52	38	36	37	38	38	39	40	41	42	43	44	5	2
51	40	52	34	45	46	47	47	48	49	50	51	52	53	6	2
														7	2
51	36	52	30	0	1	2	3	4	4	5	6	7	8	8	3
51	32	52	26	9	10	11	12	12	13	14	15	16	17	9	3
51	28	52	21	18	19	20	20	21	22	23	24	25	26		
51	24	52	17	27	27	28	29	30	31	32	33	34	35		
51	20	52	13	35	36	37	38	39	40	41	42	43	43		
51	16	52	9	44	45	46	47	48	49	50	51	51	52		
51	12	52	5	0	1	2	3	4	4	5	6	7	8	1	0
51	8	52	0	9	10	11	11	12	13	14	15	16	17	2	1
51	3	51	56	18	18	19	20	21	22	23	24	25	25	3	1
50	59	51	52	26	27	28	29	30	31	32	32	33	34	4	2
50	55	51	47	35	36	37	38	39	40	40	41	42	43	5	2
50	50	51	43	44	45	46	47	47	48	49	50	51	52	6	2
														7	3
50	46	51	39	0	1	2	3	3	4	5	6	7	8	8	3
50	42	51	34	9	10	10	11	12	13	14	15	16	17	9	4
50	37	51	30	17	18	19	20	21	22	23	23	24	25		
50	33	51	24	26	27	28	29	30	[illegible]	31	32	33	34		
50	28	51	20	35	36	37	37	[illegible]	39	40	41	42	43		
50	24	51	16	44	44	45	46	[illegible]	48	49	50	50	51		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude		Horizontal parallax.													
		53′		54′		55′		56′		57′		58′		59′	
30°	0′	44′	16″	45′	7″	45′	59″	46′	51″	47′	43″	48′	35″	49′	27″
	10	44	12	45	3	45	55	46	47	[illegible]	29	48	31	49	23
	20	44	7	44	59	45	51	46	43	[illegible]	35	48	26	49	18
	30	44	3	44	55	45	47	46	39	47	30	48	22	49	14
	40	43	59	44	51	45	43	46	34	47	26	48	17	49	9
	50	43	55	44	47	45	38	46	30	47	21	48	13	49	4
31	0	43	51	44	43	45	34	46	25	47	17	48	8	49	0
	10	43	47	44	38	45	30	46	21	47	12	48	4	48	55
	20	43	43	44	34	45	25	46	17	47	8	47	59	48	50
	30	43	39	44	30	45	21	46	12	47	3	47	54	48	46
	40	43	34	44	25	45	16	46	8	46	59	47	50	48	41
	50	43	30	44	21	45	12	46	3	46	54	47	45	48	36
32	0	43	16	44	17	45	8	45	58	46	49	47	40	48	31
	10	43	21	44	12	45	3	45	54	46	45	47	35	48	26
	20	43	17	44	8	44	58	45	49	46	40	47	31	48	21
	30	43	13	44	3	44	54	45	45	46	35	47	26	48	16
	40	43	8	43	59	44	49	45	40	46	30	47	21	48	11
	50	43	4	43	53	44	45	45	35	46	26	47	16	48	6
33	0	42	59	43	50	44	40	45	30	46	21	47	11	48	1
	10	42	55	43	45	44	35	45	26	46	16	47	6	47	56
	20	42	50	43	39	44	31	45	21	46	11	47	1	47	51
	30	42	46	43	36	44	26	45	16	46	6	46	56	47	46
	40	42	41	43	31	44	21	45	11	46	1	46	51	47	41
	50	42	37	43	26	44	16	45	6	45	56	46	46	47	36
34	0	42	32	43	22	44	12	45	1	45	51	46	41	47	30
	10	42	27	43	17	44	7	44	56	45	46	46	36	47	25
	20	42	23	43	12	44	2	44	51	45	41	46	[illegible]	47	20
	30	42	18	43	7	43	57	44	46	45	36	46	25	47	15
	40	42	13	43	3	43	52	44	41	45	31	46	20	47	9
	50	42	8	42	58	43	47	44	36	45	25	46	15	47	4
35	0	42	4	42	53	[illegible]	[illegible]	[illegible]	31	45	20	46	9	46	59
	10	41	59	42	48	43	37	44	26	45	15	46	4	46	53
	20	41	54	42	43	43	32	44	21	45	10	45	59	46	48
	30	41	49	42	38	43	27	44	16	45	5	45	53	46	42
	40	41	44	42	33	43	[illegible]	44	10	44	59	45	48	46	37
	50	41	39	42	28	[illegible]	[illegible]	44	5	44	54	45	43	46	31

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60′		61′		0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		
50′	19″	51′	11″	0	1	2	3	3	4	5	6	7	8	1′	0″
50	15	51	6	9	[illegible]	10	11	12	13	14	15	16	16	2	1
50	10	51	2	17	[illegible]	19	20	21	22	22	23	24	25	3	1
50	5	50	57	26	27	28	28	29	30	31	32	33	34	4	2
50	1	50	51	34	35	36	37	38	39	40	41	41	42	5	2
49	56	50	47	43	44	45	46	47	47	48	49	50	51	6	3
														7	3
49	51	50	43	0	1	2	3	3	4	5	6	7	8	8	4
49	46	50	38	9	9	10	11	12	13	14	15	15	16	9	4
49	42	50	33	17	18	19	20	20	21	22	23	24	25		
49	37	50	28	26	26	27	28	29	30	31	32	32	33		
49	32	50	23	34	35	36	37	38	38	39	40	41	42		
49	27	50	18	43	44	44	45	46	47	[illegible]	49	49	50		
49	22	50	13	0	1	2	3	3	4	5	6	7	8	1	0
49	17	50	8	8	9	10	11	12	13	13	14	15	16	2	1
49	12	50	3	17	18	19	19	20	21	22	23	24	24	3	1
49	7	49	58	25	26	27	28	29	30	30	31	32	33	4	2
49	2	49	52	34	35	35	36	37	38	39	40	40	41	5	2
48	57	49	47	42	43	44	45	46	47	[illegible]	[illegible]	49	[illegible]	6	3
														7	3
48	52	49	42	0	1	2	3	3	4	5	6	7	8	8	4
48	46	49	37	8	9	10	11	12	13	13	14	15	16	9	4
48	41	49	31	17	18	18	19	20	21	22	23	23	24		
48	36	49	26	25	26	27	28	28	29	30	31	32	33		
48	31	49	21	33	34	35	36	37	38	38	39	40	41		
48	26	49	15	42	43	43	44	45	46	47	48	48	49		
48	20	49	10	0	1	2	2	3	4	5	6	7	7	1	1
48	15	49	4	8	9	10	11	12	12	13	14	15	16	2	1
48	9	48	59	16	17	18	19	20	21	21	22	23	24	3	2
48	4	48	54	25	26	26	27	28	29	30	30	31	32	4	2
47	59	48	48	33	34	35	35	36	37	38	39	40	40	5	3
47	53	48	42	41	42	43	44	44	45	46	47	48	49	6	3
														7	4
47	48	48	37	0	1	2	[illegible]	[illegible]	4	5	6	7	7	8	4
47	42	48	31	8	9	10	[illegible]	[illegible]	12	13	14	15	15	9	5
47	37	48	26	16	17	18	[illegible]	[illegible]	20	21	22	23	24		
47	31	48	20	24	25	26	[illegible]	[illegible]	[illegible]	29	30	31	32		
47	25	48	14	33	33	34	[illegible]	[illegible]	37	37	38	39	40		
47	20	48	8	41	42	42	[illegible]	[illegible]	[illegible]	46	46	47	48		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53′		54′		55′		56′		57′		58′		59′	
36°	0′	41′	34″	42′	23″	43′	11″	44′	0″	44′	49″	45′	37″	46′	26″
	10	41	29	42	18	43	6	43	55	44	43	45	32	46	20
	20	41	24	42	13	43	1	43	49	44	38	45	26	46	14
	30	41	19	42	[illegible]	42	56	43	44	44	32	45	21	46	9
	40	41	14	42	2	42	51	43	39	44	27	45	15	46	3
	50	41	9	41	57	[illegible]	46	43	33	44	21	45	9	45	57
37	0	41	4	41	52	42	40	43	28	44	16	45	4	45	52
	10	40	59	41	47	42	35	43	22	44	10	44	58	45	46
	20	40	54	41	42	42	29	43	17	44	5	44	52	45	40
	30	40	49	41	36	42	24	43	12	43	59	44	47	45	34
	40	40	43	41	31	42	18	43	6	43	53	44	41	45	29
	50	40	38	41	26	42	13	43	0	43	48	44	35	45	23
38	0	40	33	41	20	42	8	42	55	43	42	44	29	45	17
	10	40	28	41	15	42	2	42	49	43	36	44	24	45	11
	20	40	22	41	10	41	57	42	44	43	31	44	18	45	5
	30	40	17	41	4	41	51	42	38	43	25	44	12	44	59
	40	40	12	40	59	41	45	42	32	43	19	44	6	44	53
	50	40	6	40	53	41	40	42	27	43	13	44	0	44	47
39	0	40	1	40	48	41	34	42	21	43	8	43	54	44	41
	10	39	56	40	42	41	29	42	15	43	2	43	48	44	35
	20	39	50	40	[illegible]	41	23	42	9	42	56	43	42	44	29
	30	39	45	40	31	41	17	42	4	42	50	43	36	44	23
	40	39	39	40	25	41	12	41	58	42	[illegible]	43	30	44	16
	50	39	34	40	20	41	6	41	52	42	38	43	24	44	10
40	0	39	28	40	14	41	0	41	46	42	32	43	18	44	4
	10	39	23	40	8	40	54	41	40	42	26	43	12	43	58
	20	39	17	40	3	40	48	41	34	42	20	43	6	43	51
	30	39	11	39	57	40	43	41	28	42	14	43	0	43	45
	40	39	6	39	51	40	37	41	22	42	8	42	53	43	39
	50	39	0	39	46	40	31	41	16	42	2	42	47	43	33
41	0	38	54	39	40	40	25	41	10	41	56	42	41	43	26
	10	38	49	39	34	40	19	41	4	41	50	42	35	43	20
	20	38	43	39	28	40	13	40	58	41	43	42	28	43	13
	30	38	37	39	22	40	7	40	52	41	37	42	22	43	7
	40	38	32	39	16	40	1	40	46	41	31	42	16	43	0
	50	38	26	39	11	39	55	40	40	41	25	42	9	42	54

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60′		61′		0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		—
47′	14″	48′	3″	0	1	2	2	3	4	5	6	6	7	1′	1″
47	8	47	57	8	9	10	10	11	12	13	14	14	15	2	1
47	3	47	51	16	17	18	18	19	20	21	22	23	23	3	2
46	57	47	45	24	25	26	27	27	28	29	30	31	31	4	2
46	51	47	39	32	33	34	35	35	36	37	38	39	39	5	3
46	45	47	33	40	41	42	43	43	44	45	46	47	47	6	3
														7	4
46	40	47	28	0	1	[illegible]	2	3	4	5	6	6	7	8	4
46	34	47	22	8	9	10	10	11	12	15	13	14	15	9	5
46	28	47	16	16	17	17	18	19	20	21	21	22	23		
46	22	47	10	24	25	25	26	27	28	29	29	30	31		
46	16	47	3	32	33	33	34	35	36	36	37	38	39		
46	10	46	57	40	40	41	42	43	44	44	45	46	47		
46	4	46	51	0	1	2	2	3	4	5	5	6	7	1	1
45	58	46	45	8	9	9	10	11	12	13	13	14	15	2	1
45	52	46	39	16	16	17	18	19	20	20	21	22	23	3	2
45	46	46	33	23	24	25	26	27	27	28	29	30	31	4	2
45	40	46	27	31	32	33	34	34	35	36	37	38	38	5	3
45	34	46	20	39	40	41	41	42	43	44	45	45	46	6	3
														7	4
45	27	46	14	0	1	2	2	3	4	5	5	6	7	8	4
45	21	46	8	8	9	9	10	11	12	12	13	14	15	9	5
45	15	46	1	15	16	17	18	19	19	20	21	22	23		
45	9	45	55	23	24	25	25	26	27	28	29	29	30		
45	3	45	49	31	32	32	33	34	35	36	36	37	38		
44	56	45	42	39	39	40	41	42	42	43	44	45	46		
44	50	45	36	0	1	1	2	3	4	5	5	6	7	1	1
44	44	45	29	8	8	9	10	11	11	12	13	14	14	2	1
44	37	45	23	15	16	17	17	18	19	20	21	21	22	3	2
44	31	45	17	23	24	24	25	26	27	27	28	29	30	4	2
44	24	45	10	30	31	32	33	33	34	35	36	36	37	5	3
44	18	45	3	38	39	40	40	41	42	43	43	44	45	6	4
														7	4
44	11	44	57	0	1	1	2	3	4	4	5	6	7	8	5
44	5	44	50	7	8	9	[illegible]	10	11	12	13	13	14	9	5
43	58	44	43	15	16	16	[illegible]	18	19	19	20	21	22		
43	52	44	37	22	23	24	25	25	26	27	28	28	29		
43	45	44	30	30	31	31	32	33	34	34	35	36	37		
43	39	44	23	37	38	39	40	[illegible]	41	42	43	43	44		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53'		54'		55'		56'		57'		58'		59'	
42°	0'	38'	20"	39'	5"	39'	49"	40'	34"	[illegible]	18"	42'	3"	42'	48"
	10	38	14	38	59	39	43	40	28	41	12	41	56	42	41
	20	38	8	38	53	39	37	40	21	41	6	41	50	42	34
	30	38	2	38	47	39	31	40	15	40	59	41	44	42	28
	40	37	57	38	41	39	25	40	9	40	53	41	37	42	21
	50	37	51	38	35	[illegible]	19	40	3	40	47	41	31	42	15
43	0	37	45	38	29	39	12	39	56	40	40	41	24	42	8
	10	37	39	38	22	39	6	39	50	40	34	41	17	42	1
	20	37	33	38	16	39	0	39	44	40	27	41	11	41	55
	30	37	27	38	10	38	54	39	37	40	21	41	4	41	48
	40	37	21	38	4	38	47	39	31	40	14	40	58	41	41
	50	37	15	37	58	38	41	39	24	40	8	40	51	41	34
44	0	37	9	37	52	38	35	39	18	40	1	40	44	41	28
	10	37	2	37	41	38	28	39	11	39	54	40	37	41	20
	20	36	56	37	39	38	22	39	5	39	48	40	31	41	14
	30	36	50	37	33	38	16	38	59	39	41	40	24	41	7
	40	36	44	37	27	38	9	38	52	39	35	40	17	41	0
	50	36	38	37	20	38	3	38	46	39	28	40	11	40	53
45	0	36	32	37	14	37	56	38	39	39	21	40	4	40	46
	10	36	25	37	8	37	50	38	32	39	15	39	57	40	39
	20	36	19	37	[illegible]	37	44	38	26	39	8	39	50	40	32
	30	36	15	36	55	37	37	38	19	39	1	39	43	40	25
	40	36	7	36	49	37	31	38	12	38	54	39	36	40	18
	50	36	0	36	42	37	24	38	6	38	48	39	29	40	11
46	0	35	54	36	36	37	[illegible]	37	59	38	41	39	22	40	4
	10	35	48	36	29	37	11	37	52	38	34	39	15	39	57
	20	35	41	36	23	37	4	37	46	38	27	39	8	39	50
	30	35	35	36	16	36	58	37	39	38	20	39	1	39	43
	40	35	29	36	9	36	51	37	32	38	13	38	54	39	36
	50	35	22	36	3	36	44	37	26	38	6	38	47	39	28
47	0	35	16	35	57	36	38	37	18	37	59	38	40	39	21
	10	35	9	35	50	36	31	37	12	37	52	38	33	39	14
	20	35	3	35	43	36	24	37	5	37	45	38	26	39	7
	30	34	56	35	37	36	17	36	58	37	38	38	19	38	59
	40	34	50	35	30	36	10	36	51	37	31	38	12	38	52
	50	34	43	35	23	36	4	36	44	37	24	38	5	38	45

TABLE VIII.

Parallax of the Moon less Refraction.

60′		61′		0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	For the altitude.	
				Proportional parts for the parallax.										′	″
43′	32″	44	17	0	1	[illegible]	2	3	4	4	5	6	7	1′	1″
43	25	44	10	7	[illegible]	[illegible]	10	10	11	12	13	[illegible]	14	2	1
43	19	44	3	15	15	16	17	18	18	19	20	21	21	3	2
43	12	43	56	22	23	24	24	25	26	27	27	28	29	4	3
43	5	43	49	29	39	31	32	32	33	34	35	35	36	5	3
42	59	43	43	37	38	38	39	40	41	41	42	43	43	6	4
														7	5
42	52	43	36	0	1	1	2	3	4	4	5	6	7	8	5
42	45	43	29	7	8	9	9	10	11	12	12	13	14	9	6
42	38	43	22	15	15	16	17	17	18	19	20	20	21		
42	31	43	15	22	22	23	24	25	25	26	27	28	28		
42	24	43	8	29	30	30	31	32	33	33	34	35	36		
42	18	43	1	36	37	38	38	39	40	41	41	42	43		
42	11	42	54	0	1	1	2	3	4	4	5	6	6	1	1
42	4	42	47	7	8	9	9	10	11	11	12	13	14	2	1
41	57	42	40	14	15	16	16	17	18	19	19	20	21	3	2
41	50	42	33	21	22	23	24	24	25	26	26	27	28	4	3
41	43	42	25	29	29	30	31	31	32	33	34	34	35	5	3
41	36	42	18	36	36	37	38	39	39	40	41	41	42	6	4
														7	5
41	29	42	11	0	1	1	2	3	4	4	5	6	6	8	5
41	22	42	4	7	8	8	9	10	11	11	12	12	13	9	6
41	14	41	57	14	15	15	16	17	18	18	19	20	20		
41	7	41	49	21	22	22	23	24	25	[illegible]	26	27	27		
41	0	41	42	28	29	29	30	31	32	32	33	34	34		
40	53	41	35	35	36	36	37	38	39	39	40	41	41		
40	46	41	27	0	1	1	2	3	4	4	5	6	6	1	1
40	39	41	20	7	8	8	9	10	10	11	12	12	13	2	1
40	31	41	13	14	14	15	16	17	17	18	19	19	20	3	2
40	24	41	5	21	21	22	23	23	24	25	25	26	27	4	3
40	17	40	58	28	28	29	30	30	31	32	32	33	34	5	4
40	9	40	50	34	35	36	36	37	38	39	39	40	41	6	4
														7	5
40	2	40	43	0	1	1	2	3	3	4	5	5	6	8	6
39	55	40	36	7	7	8	[illegible]	9	10	11	11	12	13	9	6
39	47	40	28	14	14	15	16	16	17	18	18	19	20		
39	40	40	20	20	21	22	22	23	24	24	25	26	26		
39	33	40	13	27	28	28	29	30	30	31	32	32	33		
39	25	40	5	34	34	35	36	[illegible]	37	38	39	39	40		

TABLE V[illegible].

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		[illegible]		54′		55′		56′		57′		58′		59′	
48°	0′	34′	37″	35′	17″	35′	57″	36′	37″	[illegible]	[illegible]	37′	57″	38′	37″
	10	34	30	[illegible]	10	35	50	36	30	37	10	37	50	38	30
	20	34	23	35	3	35	43	36	23	37	3	37	43	38	23
	30	34	17	34	56	35	36	36	16	36	56	37	36	38	15
	40	[illegible]	10	34	50	35	29	36	9	36	49	37	28	38	8
	50	[illegible]	3	34	43	[illegible]	22	36	2	36	41	37	21	38	0
49	0	33	57	34	36	35	16	35	55	36	34	37	14	37	53
	10	33	50	34	29	35	9	35	48	36	27	37	6	37	45
	20	33	43	34	22	35	2	35	41	36	20	36	59	37	38
	30	33	37	34	16	34	55	35	34	36	12	36	51	37	30
	40	33	30	34	9	34	48	35	26	36	5	36	44	37	23
	50	33	23	34	2	34	40	35	19	37	[illegible]	36	37	37	15
50	0	33	16	33	55	34	33	35	12	35	51	36	29	37	8
	10	33	[illegible]	33	48	[illegible]	26	35	5	35	43	36	22	37	0
	20	33	[illegible]	33	41	34	19	34	58	35	36	36	14	36	52
	30	33	[illegible]	33	[illegible]	34	12	34	50	35	28	36	7	36	45
	40	32	[illegible]	33	[illegible]	34	5	34	43	35	21	35	59	36	37
	50	32	42	33	20	33	58	34	36	35	14	35	51	36	29
51	0	32	[illegible]	33	13	33	[illegible]	34	28	35	6	35	44	[illegible]	22
	10	32	[illegible]	33	6	33	[illegible]	34	21	34	59	35	36	36	14
	20	32	21	32	59	33	36	34	14	34	51	35	29	36	6
	30	32	14	32	52	[illegible]	29	34	6	34	44	35	21	35	58
	40	32	7	33	[illegible]	33	22	33	59	34	36	35	13	35	51
	50	32	0	32	37	33	14	33	52	34	29	35	6	35	43
52	0	31	53	32	30	[illegible]	[illegible]	33	44	34	21	34	58	35	35
	10	31	46	32	23	33	[illegible]	[illegible]	37	34	13	34	50	35	27
	20	31	39	32	16	32	53	33	29	34	6	34	43	35	19
	30	31	32	32	9	32	45	33	22	33	58	34	35	35	11
	40	31	25	32	1	32	38	33	14	33	51	34	27	35	3
	50	31	18	31	54	32	30	33	7	33	43	34	19	34	55
53	0	31	11	31	47	32	23	32	59	33	35	34	11	34	48
	10	31	4	31	40	32	16	32	52	33	28	34	4	34	40
	20	30	57	31	33	32	8	32	44	33	20	33	56	34	32
	30	30	49	31	25	32	1	32	36	33	12	33	48	34	24
	40	30	42	31	18	31	53	32	29	33	4	33	40	34	15
	50	30	35	31	10	31	45	32	21	32	57	33	32	34	7

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60′		61′		0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		—
39′	18″	39′	58″	[illegible]	1	[illegible]	2	3	3	4	5	5	6	1	1
39	10	39	50	[illegible]	7	8	9	9	10	11	11	12	13	2	1
39	3	39	42	13	14	15	15	16	17	17	18	19	19	3	2
38	55	39	35	20	21	21	22	23	23	24	25	25	26	4	3
38	47	39	27	27	27	28	29	29	30	[illegible]	31	32	32	5	4
38	40	39	19	33	34	34	35	36	36	37	38	38	39	6	4
														7	5
38	32	39	12	0	1	1	2	3	3	4	5	5	6	8	6
38	25	39	4	6	7	8	8	9	10	10	11	12	12	9	6
38	17	38	56	13	14	14	15	16	16	17	18	18	19		
38	9	38	48	19	20	21	21	22	23	23	24	25	25		
38	2	38	41	26	27	27	28	29	29	30	31	31	32		
37	54	38	33	32	33	34	34	35	36	36	37	38	38		
37	46	38	25	0	1	1	2	3	[illegible]	4	4	5	6	1	1
37	38	38	17	6	7	8	8	9	10	10	11	11	12	2	2
37	31	38	9	13	13	14	15	15	16	17	[illegible]	18	18	3	2
37	23	38	1	19	20	20	21	22	22	23	24	24	25	4	3
37	15	37	53	25	26	27	27	28	29	29	30	31	31	5	4
37	7	37	45	32	32	33	34	34	35	36	36	37	38	6	5
														7	5
36	59	37	37	0	1	1	2	2	3	4	4	5	6	8	[illegible]
36	52	37	29	6	7	7	8	9	9	10	11	11	12	9	
36	44	37	21	12	13	14	14	15	16	[illegible]	17	17	18		
36	36	37	13	19	19	20	21	21	22	[illegible]	23	24	24		
36	28	37	5	25	26	26	27	27	28	[illegible]	29	30	30		
36	20	36	57	31	32	32	33	34	34	35	35	36	37		
36	12	36	49	0	1	1	2	2	3	4	4	5	5	1	1
36	4	36	41	6	7	7	[illegible]	9	9	10	10	11	12	2	2
35	56	36	33	12	13	13	14	15	15	16	16	17	18	3	2
35	48	36	24	18	19	19	20	21	21	22	23	23	24	4	3
35	40	36	16	24	25	26	26	27	27	28	29	29	30	5	4
35	32	36	8	30	31	32	32	33	33	34	35	35	36		5
														7	5
35	24	36	0	0	1	1	2	2	3	4	4	5	5	8	6
35	15	35	51	6	7	7	8	8	9	10	10	11	11	9	7
35	17	35	43	12	12	13	14	14	15	15	16	17	17		
34	59	35	35	18	18	19	20	20	21	21	22	23	23		
34	51	35	27	24	24	25	26	26	27	27	28	29	29		
34	43	35	18	30	30	31	32	32	[illegible]	[illegible]	34	35	35		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax. 53′		54′		55′		56′		57′		58′		59′	
51°	0′	30	28	31′	8″	31′	38″	32′	13″	32′	[illegible]	33′	24″	[illegible]	59″
	10	30	21	30	56	31	31	32	6	32	41	33	16	33	51
	20	30	13	30	48	31	23	31	58	32	33	33	8	33	43
	30	30	6	30	41	31	16	31	51	32	25	33	0	33	35
	40	29	59	30	33	31	8	31	43	32	18	32	52	33	27
	50	29	51	30	26	31	1	31	35	32	10	32	44	33	19
55	0	29	44	30	19	30	53	31	27	32	2	32	36	33	11
	10	29	37	30	11	30	45	31	20	31	54	32	28	33	2
	20	29	29	30	4	30	38	31	12	31	46	32	20	32	54
	30	29	22	29	56	30	30	31	4	31	38	32	12	32	46
	40	29	15	29	47	30	21	30	55	31	29	32	3	32	37
	50	29	7	29	40	30	14	30	47	31	21	31	55	32	28
56	0	29	0	29	35	30	7	30	40	31	14	31	48	32	21
	10	28	52	29	26	29	59	30	3	31	6	31	39	32	14
	20	28	45	29	18	29	51	30	25	30	58	31	[illegible]	32	4
	30	28	37	29	11	29	44	30	17	30	50	31	23	31	56
	40	28	30	29	3	29	36	30	9	30	42	31	15	31	48
	50	28	22	28	55	29	28	30	1	30	34	31	7	31	39
57	0	28	14	28	48	29	20	29	53	30	26	30	58	31	31
	10	28	7	28	40	29	12	29	45	30	18	30	50	31	22
	20	28	0	28	32	29	5	29	37	30	9	30	42	31	14
	30	27	52	28	24	28	57	29	29	30	1	30	33	31	6
	40	27	45	28	17	28	49	29	21	29	53	30	25	30	57
	0	27	37	28	9	28	41	29	13	29	45	30	17	30	49
58	0	27	30	28	1	28	33	29	5	29	37	30	9	30	40
	10	27	22	27	53	28	25	28	57	29	29	30	0	30	32
	20	27	14	27	46	28	17	28	49	29	20	29	52	30	23
	30	27	7	27	38	28	9	28	41	29	12	29	43	30	15
	40	26	59	27	30	28	1	28	33	29	4	29	35	30	6
	50	26	51	27	22	27	53	28	24	28	56	29	27	29	58
59	0	26	44	27	15	27	45	28	16	28	47	29	18	29	49
	10	26	36	27	7	27	37	28	8	28	39	29	10	29	40
	20	26	28	26	59	27	30	28	0	28	31	29	1	29	32
	30	26	20	26	51	27	21	27	52	28	22	28	53	29	23
	40	26	13	26	43	27	13	27	44	28	14	28	44	29	14
	50	26	5	26	35	27	5	27	35	28	6	28	36	29	6

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for the parallax.										For the altitude.	
60′		61′		0	1	2″	3	4″	[illegible]	[illegible]	7″	8″	9″		—
34′	35′	35′	10	0	1	1	2	2	3	3	4	[illegible]	5	1′	1″
34	26	35	2	6	6	7	8	8	9	9	10	10	11	2	2
34	18	34	53	12	12	13	13	14	15	15	16	16	17	3	2
34	10	34	45	17	18	19	19	20	20	21	21	22	23	4	3
34	2	34	36	23	24	24	25	26	26	27	27	28	[illegible]	5	4
33	53	34	28	29	30	30	31	31	32	32	33	34	[illegible]	6	5
														7	6
33	45	34	19	0	1	1	2	2	3	3	4	5	5	8	6
33	37	34	11	6	6	7	7	8	8	9	10	10	11	9	7
33	28	34	2	11	12	12	13	14	14	15	15	16	16		
33	20	33	54	17	18	18	19	19	20	20	21	22	22		
33	11	33	44	23	23	24	24	25	25	26	27	27	28		
33	2	33	[illegible]	[illegible]	29	29	30	31	31	32	32	33	33		
32	57	33	28	0	1	1	2	2	3	3	4	4	5	1	1
32	46	33	20	6	6	7	7	8	8	9	9	10	10	2	2
32	38	33	11	11	12	12	13	13	14	14	15	15	16	3	2
32	29	33	2	17	17	18	18	13	19	[illegible]	20	[illegible]	22	4	3
32	21	32	54	22	23	23	24	24	25	[illegible]	26	26	27	5	4
32	12	32	45	28	28	29	29	30	30	31	31	32	33	[illegible]	5
														7	6
32	4	32	36	0	1	1	2	2	3	3	4	4	5	8	6
31	55	32	28	5	6	6	7	8	8	9	9	10	11	9	7
31	47	32	19	11	11	12	12	13	13	14	14	15	16		
31	38	32	10	16	17	17	16	18	18	[illegible]	20	20	21		
31	29	32	1	21	22	23	23	24	24	25	[illegible]	26	26		
31	21	31	53	27	27	28	28	29	30	31	31	31	32		
31	12	31	44	0	1	1	2	2	3	3	4	4	5		
31	3	31	35	5	6	6	[illegible]	7	8	8	9	9	10	1	
30	55	31	26	10	11	11	12	13	15	14	14	15	15	2	1
30	46	31	17	16	16	17	17	18	18	19	19	20	20	3	2
30	37	31	9	21	21	22	22	[illegible]	23	24	25	25	26	4	3
30	29	31	0	26	27	27	28	28	29	29	30	30	31	5	3
														6	4
														7	5
30	20	30	51	0	1	1	2	2	3	3	4	4	5	8	6
30	11	30	42	5	6	6	7	7	8	8	9	9	10	9	7
30	2	30	33	10	11	11	12	12	13	13	14	14	15		
29	54	30	24	15	16	16	17	17	18	18	19	19	20		
29	45	30	15	20	21	21	22	22	23	[illegible]	24	24	25		
29	36	30	6	25	[illegible]	26	27	27	28	26	29	29	30		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53'		54'		55'		56'		57'		58'		59'	
60°	0	25'	57"	26'	27"	26'	57"	27'	27"	27'	57"	28'	27"	28'	57"
	10	25	49	[illegible]	19	26	49	27	19	27	[illegible]	28	19	28	48
	20	25	[illegible]	26	[illegible]	26	41	27	11	27	40	28	10	28	40
	30	25	34	26	3	26	[illegible]	27	2	27	32	28	1	28	31
	40	25	26	25	56	26	25	26	[illegible]	27	23	27	53	28	22
	50	25	18	25	47	26	16	26	46	27	15	27	44	28	13
61	0	25	10	25	39	26	8	26	37	27	6	27	36	28	5
	10	25	2	25	31	26	0	26	29	26	58	27	27	27	56
	20	24	54	25	23	25	52	26	21	26	49	27	18	27	47
	30	24	46	25	15	25	44	26	12	26	41	27	10	27	38
	40	24	39	25	7	25	35	26	4	26	32	27	1	27	29
	50	24	31	24	59	25	27	25	56	26	24	26	52	27	21
62	0	24	23	24	51	[illegible]	[illegible]	[illegible]	47	26	15	26	43	27	12
	10	24	15	24	[illegible]	25	11	25	39	26	7	26	35	27	3
	20	24	7	[illegible]	[illegible]	25	[illegible]	[illegible]	30	25	58	26	[illegible]	26	54
	30	23	59	24	26	24	54	[illegible]	[illegible]	25	50	[illegible]	17	26	45
	40	23	51	24	17	24	46	[illegible]	13	25	41	26	[illegible]	26	36
	50	23	43	24	10	24	[illegible]	25	[illegible]	25	32	26	0	26	27
63	0	23	35	24	2	24	[illegible]	24	50	[illegible]	[illegible]	25	51	26	[illegible]
	10	23	27	23	54	24	21	24	48	[illegible]	1	25	42	26	9
	20	23	19	23	45	24	12	24	[illegible]	[illegible]	6	[illegible]	[illegible]	26	0
	30	23	11	23	37	24	[illegible]	24	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51
	40	23	2	23	29	[illegible]	[illegible]	24	[illegible]	[illegible]	49	25	15	[illegible]	[illegible]
	50	22	54	23	21	23	47	[illegible]	11	[illegible]	40	25	7	[illegible]	[illegible]
64	0	22	46	[illegible]	11	23	[illegible]	24	[illegible]	24	1	24	[illegible]	[illegible]	[illegible]
	10	22	38	23	4	23	30	23	[illegible]	[illegible]	[illegible]	24	19	[illegible]	[illegible]
	20	22	30	22	56	23	22	23	41	[illegible]	[illegible]	24	40	[illegible]	[illegible]
	30	22	22	22	48	23	14	23	[illegible]	24	[illegible]	[illegible]	1	24	57
	40	22	14	22	39	23	5	[illegible]	[illegible]	23	5	24	[illegible]	[illegible]	48
	50	22	[illegible]	22	31	22	[illegible]	[illegible]	22	[illegible]	48	24	[illegible]	24	39
65	0	21	57	22	[illegible]	22	48	23	[illegible]	23	39	24	1	24	0
	10	21	[illegible]	22	14	22	40	23	5	23	30	23	[illegible]	24	20
	20	21	11	22	[illegible]	22	31	22	[illegible]	23	21	23	46	24	11
	30	21	[illegible]	21	58	22	23	22	[illegible]	23	12	23	37	24	2
	40	21	[illegible]	21	[illegible]	22	14	22	39	23	[illegible]	23	28	23	53
	50	21	16	21	41	22	5	22	30	22	55	23	19	23	44

TABLE VIII.

Parallax of the Moon less Refraction.

				Proportional parts for [illegible]										For the altitude.	
60'		61'		0"	1"	2"	3"	4"	5"	6"	7"	8"	9"		—
29'	27"	29'	57"	0	0	1	1	2	2	3	3	4	4	1'	1"
29	18	29	48	5	5	6	6	7	7	8	8	9	9	2	2
29	9	29	39	10	10	11	11	12	12	13	13	14	14	3	3
29	1	29	30	15	15	16	16	17	17	18	18	19	19	4	3
28	52	29	21	20	20	21	21	22	22	22	23	21	[illegible]	5	4
28	43	29	12	25	25	26	26	27	27	28	28	29	29	6	5
														7	6
28	34	29	3	0	0	1	1	2	2	3	3	4	4	8	7
28	25	28	54	5	5	6	6	7	7	8	8	9	9	9	8
28	16	28	45	10	10	10	11	11	12	12	13	13	14		
28	7	28	3[illegible]	14	15	15	16	16	17	17	18	18	19		
27	58	28	26	19	20	20	21	21	21	22	22	2[illegible]	23		
27	49	28	17	24	24	25	25	26	26	27	27	28	28		
27	40	28	8	0	0	1	1	2	2	3	3	4	4	1	1
27	31	27	59	5	5	6	6	6	7	7	8	8	9	2	2
27	22	27	50	9	10	10	11	11	12	12	12	13	13	3	3
27	13	27	41	14	14	15	15	16	16	17	17	18	18	4	4
27	4	27	31	18	19	19	20	20	21	21	22	22	23	5	4
26	54	27	22	23	24	24	24	25	25	26	26	27	27	6	5
														7	6
26	45	27	13	0	0	1	1	2	2		3	[illegible]	4	8	7
26	36	27	3	4	5	5	6	6	7	7	8	[illegible]	8	9	8
26	27	26	54	9	9	10	10	11	11	12	12	12	13		
26	18	26	45	14	13	14	15	15	16	16	17	17	17		
26	9	26	35	18	18	19	19	20	20	21	21	21	22		
26	0	26	26	22	23	23	24	24	25	25	25	26	26		
25	50	26	17	0	0	1	1	2	2	3	3	3	4	1	1
25	41	26	7	4	5	5	[illegible]	6	6	7	7	8	8	2	2
25	32	25	58	9	9	9	10	10	11	11	12	12	12	3	3
25	23	25	45	13	13	14	14	15	15	15	16	16	17	4	4
25	13	25	9	17	18	18	18	19	19	20	20	21	21	5	4
25	4	25	30	22	22	22	23	23	24	24	25	25	25	6	5
														7	6
24	55	25	20	0	0	1	1	2	2	2	3	3	4	8	7
24	46	25	11	4	5	5	5	6	6	7	7	7	8	9	8
24	36	25	1	8	9	9	10	10	10	11	11	12	12		
24	27	24	52	12	13	13	14	14	14	15	15	16	16		
24	18	24	42	17	17	17	18	18	19	19	19	20	20		
24	8	24	33	21	21	22	23	23	23	23	24	24	24		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.	Horizontal parallax. 53′		54′		55′		56′		57′		58′		59′	
66° 0′	21′	8″	21′	32″	21′	57″	22′	21″	22′	46″	23′	10″	23′	34″
10	21	0	21	24	21	48	22	13	22	37	23	1	23	25
20	20	52	21	16	21	40	22	4	22	28	22	52	23	16
30	20	44	21	7	21	31	21	55	22	19	22	43	23	7
40	20	35	20	59	21	23	21	46	22	10	22	34	22	58
50	20	27	20	50	21	14	21	37	22	1	22	25	22	48
67 0	20	18	20	41	21	5	21	29	21	52	22	16	22	39
10	20	10	20	33	20	57	21	20	21	43	22	6	22	30
20	20	2	20	25	20	48	21	11	21	34	21	57	22	20
30	19	53	20	16	20	39	21	2	21	25	21	48	22	11
40	19	45	20	8	20	31	20	53	21	16	21	39	22	2
50	19	37	19	59	20	22	20	45	21	7	21	30	21	52
68 0	19	28	19	51	20	13	20	36	20	58	21	21	21	43
10	19	20	19	42	20	4	20	27	20	49	21	11	21	34
20	19	11	19	34	19	56	20	18	20	40	21	2	21	24
30	19	3	19	25	19	47	20	9	20	31	20	53	21	15
40	18	55	19	16	19	38	20	0	20	22	20	44	21	6
50	18	46	19	8	19	29	19	51	20	13	20	34	20	56
69 0	18	38	18	59	19	21	19	42	20	4	20	25	20	47
10	18	29	18	51	19	12	19	33	19	55	20	16	20	37
20	18	21	18	42	19	3	19	24	19	46	20	7	20	28
30	18	12	18	33	18	54	19	15	19	36	19	57	20	18
40	18	4	18	25	18	46	19	6	19	27	19	48	20	9
50	17	56	18	16	18	37	18	57	19	18	19	39	20	0
70 0	17	47	18	7	18	28	18	49	19	9	19	30	19	50
10	17	38	17	59	18	19	18	39	19	0	19	20	19	41
20	17	30	17	50	18	10	18	30	18	51	19	11	19	31
30	17	21	17	41	18	1	18	21	18	41	19	1	19	22
40	17	13	17	[illegible]	17	53	18	12	18	32	18	52	19	12
50	17	[illegible]	17	24	17	44	18	3	18	23	18	43	19	2
71 0	16	56	17	15	17	35	17	54	18	14	18	33	18	53
10	16	47	17	6	17	26	17	45	18	5	18	24	18	43
20	16	39	16	58	17	17	17	36	17	55	18	15	18	34
30	16	30	16	49	17	8	17	27	17	46	18	5	18	24
40	16	21	16	40	16	59	17	18	17	37	17	56	18	15
50	16	13	16	32	16	50	17	9	17	28	17	46	18	5

TABLE VIII.

Parallax of the Moon less Refraction.

60′		61′		Proportional parts for the parallax.										For the Altitude.	
				0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		—
23′	59″	24′	23″	0	0	1	1	2	2	2	3	3	4	1′	1″
23	50	24	14	4	4	5	5	6	6	6	7	7	8	2	2
23	40	24	4	8	8	9	9	10	10	10	11	11	12	3	3
23	31	23	55	12	12	13	13	14	14	14	15	15	16	4	4
23	21	23	45	16	16	17	17	18	18	18	19	19	20	5	5
23	12	23	35	20	20	21	21	21	22	22	23	23	23	6	5
														7	6
23	2	23	26	0	0	1	1	2	2	2	3	3	3	8	7
22	53	23	16	4	4	5	5	5	6	6	6	7	7	9	8
22	44	23	7	8	8	8	9	9	10	10	10	11	11		
22	34	22	57	11	12	12	13	13	13	14	14	14	15		
22	25	22	47	15	16	16	16	17	17	18	18	18	19		
22	15	22	38	19	19	20	20	21	21	21	22	22	22		
22	6	22	28	0	0	1	1	2	2	2	3	3	3	1	1
21	56	22	18	4	4	4	5	5	5	6	6	7	7	2	2
21	46	22	9	7	8	8	8	9	9	10	10	10	11	3	3
21	37	21	59	11	11	12	12	12	13	13	14	14	14	4	4
21	27	21	49	15	16	15	16	16	16	17	17	18	18	5	5
21	18	21	40	18	19	19	19	20	20	20	21	21	22	6	5
														7	6
21	8	21	30	0	0	1	1	1	2	2	2	3	3	8	7
20	59	21	20	4	4	4	5	5	5	6	6	6	7	9	8
20	49	21	10	7	7	8	8	8	9	9	9	10	10		
20	39	21	0	11	11	11	12	12	12	13	13	13	14		
20	30	20	51	14	14	15	15	15	16	16	16	17	17		
20	20	20	41	18	18	18	19	19	19	20	20	20	21		
20	11	20	31	0	0	1	1	1	2	2	2	3	3	1	1
20	1	20	21	3	4	4	4	5	5	5	6	6	6	2	2
19	51	20	11	7	7	7	8	8	8	9	9	9	10	3	3
19	42	20	2	10	10	11	11	11	12	12	12	13	13	4	4
19	32	19	52	14	14	14	14	15	15	15	16	16	16	5	5
19	22	19	42	17	17	17	18	18	18	19	19	19	20	6	6
														7	6
19	12	19	32	0	0	1	1	1	2	2	2	3	3	8	7
19	3	19	22	3	3	4	4	4	5	5	5	6	6	9	8
18	53	19	12	6	7	7	7	8	8	8	9	9	9		
18	43	19	2	10	10	10	10	11	11	11	12	12	12		
18	33	18	52	13	13	13	14	14	14	15	15	15	16		
18	24	18	42	16	16	16	17	17	17	18	18	18	19		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.	Horizontal parallax.						
	53′	54′	55′	56′	57′	58′	59′
72° 0′	16′ 4″	16′ 23″	16′ 41″	17′ 0″	17′ 18″	17′ 37″	17′ 55″
10	15 56	16 14	16 32	16 51	17 9	17 27	17 46
20	15 47	16 5	16 23	16 42	17 0	17 18	17 36
30	15 38	15 56	16 14	16 32	16 50	17 9	17 27
40	15 30	15 47	16 5	16 23	16 41	16 59	17 17
50	15 21	15 39	15 56	16 14	16 32	16 50	17 7
73 0	15 12	15 30	15 47	16 5	16 22	16 40	16 58
10	15 4	15 21	15 38	15 56	16 13	16 31	16 48
20	14 55	15 12	15 29	15 47	16 4	16 21	16 38
30	14 46	15 3	15 20	15 37	15 54	16 11	16 29
40	14 38	14 56	15 11	15 28	15 45	16 2	16 19
50	14 29	14 46	15 2	15 19	15 36	15 52	16 9
74 0	14 20	14 37	14 53	15 10	15 26	15 43	15 59
10	14 11	14 27	14 43	15 0	15 16	15 33	15 49
20	14 3	14 19	14 35	14 51	15 6	15 21	15 40
30	13 54	14 10	14 26	14 42	14 58	15 14	15 30
40	13 45	14 1	14 17	14 33	14 49	15 5	15 20
50	13 37	13 52	14 8	14 24	14 39	14 55	15 11
75 0	13 28	13 43	13 59	14 14	14 30	14 45	15 1
10	13 19	13 34	13 50	14 5	14 20	14 36	14 51
20	13 10	13 25	13 41	13 56	14 11	14 26	14 41
30	13 1	13 16	13 31	13 47	14 2	14 17	14 31
40	12 53	13 8	13 22	13 37	13 52	14 7	14 22
50	12 44	12 59	13 13	13 28	13 42	13 57	14 12
76 0	12 35	12 49	13 4	13 19	13 33	13 48	14 2
10	12 26	12 41	12 55	13 9	13 24	13 38	13 52
20	12 17	12 32	12 46	13 0	13 14	13 28	13 43
30	12 9	12 23	12 37	12 51	13 5	13 19	13 33
40	12 0	12 13	12 27	12 41	12 55	13 9	13 22
50	11 51	12 4	12 18	12 31	12 45	12 59	13 12
77 0	11 42	11 56	12 9	12 23	12 36	12 50	13 3
10	11 33	11 46	11 59	12 13	12 26	12 39	12 53
20	11 25	11 37	11 50	12 3	12 17	12 30	12 43
30	11 16	11 29	11 42	11 55	12 8	12 21	12 34
40	11 7	11 20	11 32	11 45	11 58	12 11	12 24
50	10 58	11 11	11 23	11 36	11 48	12 1	12 14

TABLE VIII.

Parallax of the Moon less Refraction.

60′		61′		Proportional parts for the parallax										For the altitude.	
				0″	1″	2″	3″	4″	5″	6″	7″	8″	9″		—
18′	14′	18′	32′	0	0	1	1	1	2	2	2	2	3	1′	1″
18	4	18	23	3	3	4	4	4	5	5	5	5	6	2	2
17	54	18	13	6	6	7	7	7	8	8	8	8	9	3	3
17	45	18	3	9	9	10	10	10	11	11	11	11	12	4	4
17	35	17	53	12	12	13	13	13	14	14	14	14	15	5	5
17	25	17	43	15	15	16	16	16	17	17	17	17	18	6	6
														7	7
17	15	17	33	0	0	1	1	1	1	2	2	2	3	8	8
17	5	17	23	3	3	3	4	4	4	5	5	5	5	9	9
16	55	17	13	6	6	6	7	7	7	7	8	8	8		
16	46	17	3	9	9	9	9	[illegible]	10	10	11	11	11		
16	36	16	53	11	12	12	12	12	13	13	13	14	14		
16	26	16	43	14	14	15	15	15	16	16	16	16	17		
16	16	16	32	0	0	1	1	1	1	2	2	2	2	1	1
16	6	16	21	3	3	3	3	4	4	4	5	5	5	2	2
15	56	16	12	5	6	6	6	6	7	7	7	7	8	3	3
15	46	16	2	8	8	9	9	9	9	10	10	10	10	4	4
15	36	15	52	11	11	11	11	12	12	12	13	13	13	5	5
15	26	15	42	13	14	14	14	14	13	15	15	15	16	6	6
														7	7
15	16	15	32	0	0	1	1	1	1	2	2	2	2	8	8
15	7	15	22	3	3	3	3	4	4	4	4	5	5	9	9
14	57	15	12	5	5	6	6	6	6	7	7	7	7		
14	47	15	2	8	8	8	8	9	9	9	9	10	10		
14	37	14	52	10	10	11	11	11	11	12	12	12	12		
14	27	14	41	13	13	13	13	14	14	14	14	15	15		
14	17	14	31	0	0	0	1	1	1	1	2	2	2	1	1
14	7	14	21	2	3	3	3	3	3	4	4	4	4	2	2
13	57	14	11	5	5	5	5	6	6	6	6	7	7	3	3
13	47	14	1	7	7	7	8	8	8	8	9	9	9	4	4
13	36	13	50	9	10	10	10	10	10	11	11	11	11	5	5
13	26	13	40	12	12	12	12	13	13	13	13	14	14	6	6
														7	7
13	17	13	30	0	0	0	1	1	1	1	2	2	2	8	8
13	6	13	19	2	2	3	3	3	3	4	4	4	4	9	9
12	56	13	9	4	5	5	5	5	6	6	6	6	6		
12	47	13	0	7	7	7	7	7	8	8	8	8	9		
12	36	12	49	9	9	9	9	10	10	10	10	10	11		
12	26	12	39	11	11	11	12	12	12	12	12	13	13		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.													
		53′		54′		55′		56′		57′		58′		59′	
78°	0′	10	49′	11′	1″	11′	14′	11′	26′	11′	39′	11′	51′	12′	4′
	10	10	40	10	52	11	5	11	17	11	29	11	42	11	54
	20	10	31	10	43	10	55	11	8	11	20	11	32	11	44
	30	10	22	10	34	10	45	10	58	11	10	11	22	11	34
	40	10	14	10	25	10	37	10	49	11	1	11	12	11	24
	50	10	5	10	16	10	28	10	39	10	51	11	3	11	14
79	0	9	56	10	7	10	19	10	30	10	41	10	53	11	4
	10	9	47	9	58	10	9	10	21	10	32	10	43	10	54
	20	9	38	9	49	10	0	10	11	10	22	10	33	10	44
	30	9	29	9	40	9	51	10	2	10	13	10	24	10	35
	40	9	20	9	31	9	42	9	52	10	3	10	14	10	25
	50	9	11	9	22	9	32	9	43	9	53	10	4	10	15
80	0	9	2	9	13	9	23	9	33	9	44	9	53	10	5
	10	8	53	9	3	9	14	9	24	9	34	9	44	9	55
	20	8	44	8	54	9	4	9	14	9	25	9	35	9	45
	30	8	35	8	45	8	55	9	5	9	15	9	25	9	35
	40	8	26	8	36	8	46	8	56	9	5	9	15	9	25
	50	8	17	8	27	8	37	8	46	8	55	9	5	9	15
81	0	8	8	[illegible]	1	8	27	8	37	8	46	8	55	9	5
	10	7	59	8	9	8	18	8	27	8	36	8	[illegible]	8	55
	20	7	51	8	0	8	9	8	18	8	27	8	[illegible]	8	45
	30	7	42	7	50	7	59	8	9	8	17	8	[illegible]	8	35
	40	7	33	7	41	7	50	7	59	8	7	8	16	8	25
	50	7	24	7	32	7	41	7	49	7	58	8	[illegible]	8	15
82	0	7	15	7	23	7	31	7	40	7	48	7	[illegible]	[illegible]	[illegible]
	10	7	6	7	14	7	22	7	30	7	[illegible]	7	[illegible]	[illegible]	[illegible]
	20	6	57	7	[illegible]	7	13	7	21	7	29	7	37	[illegible]	[illegible]
	30	6	48	6	[illegible]	7	3	7	11	7	19	7	27	7	35
	40	6	39	6	46	6	54	7	2	7	9	7	17	7	25
	50	6	30	6	37	6	45	6	52	6	59	7	7	7	14
83	0	6	21	6	28	6	35	6	42	6	50	6	57	7	4
	10	6	12	6	19	6	26	6	33	6	40	6	47	6	54
	20	6	3	6	10	6	16	6	23	6	30	6	37	6	44
	30	5	53	6	0	6	7	6	14	6	21	6	27	6	34
	40	5	44	5	51	5	58	6	4	6	11	6	17	6	24
	50	5	35	5	42	5	49	5	55	6	1	6	8	6	14

TABLE VIII.

Parallax of the Moon less R[illegible]

60′	61′	Proportional parts for the parallax.										For the altitude.	
60′	61′	0″	1″	2″	3″	4″	5″	6″	7″	8″	[illegible]		
12′ 16″	12′ 29″	0	0	0	1	1	1	1	1	2	2	1′	1″
12 6	12 19	2	2	2	3	3	3	3	3	4	4	2	2
11 56	12 8	4	4	4	5	5	5	5	5	6	6	3	3
11 46	11 58	6	6	6	7	7	7	7	7	8	8	4	4
11 36	11 48	8	8	8	9	9	9	9	9	10	10	5	5
11 26	11 38	10	10	10	11	11	11	11	11	12	12	6	6
												7	7
11 16	11 27	0	0	0	1	1	1	1	1	1	2	8	8
11 6	11 17	2	2	2	2	3	3	3	3	3	3	9	9
10 56	11 7	4	4	4	4	4	5	5	5	5	5		
10 45	10 56	5	6	6	6	6	6	7	7	7	7		
10 35	10 46	7	7	8	8	8	8	8	9	9	9		
10 25	10 36	9	9	9	10	10	10	10	10	11	11		
10 15	10 26	0	0	0	0	1	1	1	1	1	1	1	1
10 5	10 15	2	2	2	2	2	2	3	3	3	3	2	2
9 55	10 5	3	3	4	4	4	4	4	4	5	5	3	3
9 45	9 55	5	5	5	5	6	6	6	6	6	6	4	4
9 34	9 44	7	7	7	7	7	7	8	8	8	8	5	5
9 24	9 34	8	8	9	9	9	9	9	9	10	10	6	6
												7	7
9 14	9 24	0	0	0	0	1	1	1	1	1	1	8	8
9 4	9 13	1	2	2	2	2	2	2	3	3	3	9	9
8 54	9 3	3	3	3	3	4	4	4	4	4	4		
8 44	8 52	4	5	5	5	5	5	5	5	6	6		
8 33	8 42	6	6	6	6	7	7	7	7	7	7		
8 23	8 32	7	8	8	8	8	8	8	8	9	9		
8 13	8 21	0	0	0	0	1	1	1	1	1	1	1	1
8 3	8 11	1	1	2	2	2	2	2	2	2	2	2	2
7 53	8 1	3	3	3	3	3	3	3	4	4	4	3	3
7 42	7 50	4	4	4	4	4	5	5	5	5	5	4	4
7 32	7 40	5	5	5	6	6	6	6	6	6	6	5	5
7 22	7 29	7	7	7	7	7	7	7	7	8	8	6	6
												7	7
7 12	7 19	0	0	0	0	0	1	1	1	1	1	8	8
7 2	7 9	1	1	1	1	2	2	2	2	2	2	9	9
6 51	6 58	2	2	2	3	3	3	3	3	3	3		
6 41	6 48	3	4	4	4	4	4	4	4	4	4		
6 31	6 37	5	5	5	5	5	5	5	5	5	6		
6 21	6 27	6	6	6	6	6	6	6	6	7	7		

TABLE VIII.

Parallax of the Moon less Refraction.

Apparent altitude.		Horizontal parallax.						
		53'	54	55'	56'	57'	58'	59'
84	0	5' 26	5' 32	5' 39	5' 45'	5' 52	5' 58"	6' 4"
	10	5 17	5 23	5 30	5 36	5 [illegible]	5 [illegible]	5 54
	20	5 8	5 14	5 21	5 26	5 32	5 [illegible]	5 44
	30	4 59	5 5	5 11	5 17	5 22	5 28	5 34
	40	4 50	4 56	[illegible] 1	5 7	5 [illegible]	5 18	5 24
	50	4 41	4 47	[illegible] 52	4 57	5 [illegible]	5 8	5 14
85	0	4 32	4 37	4 43	4 48	4 53	4 58	5 4
	10	4 23	4 28	4 33	4 38	4 43	4 48	4 53
	20	4 14	4 19	4 24	4 29	4 34	4 38	4 43
	30	4 5	4 10	4 14	4 19	4 24	4 29	4 33
	40	3 56	4 1	4 5	4 10	4 14	4 19	4 23
	50	3 47	3 51	3 56	4 [illegible]	4 [illegible]	4 9	4 13
86	0	3 38	3 42	[illegible] 46	3 50	[illegible] 55	3 59	4 3
	10	3 29	3 33	3 37	3 41	3 [illegible]	3 49	3 53
	20	3 20	3 24	3 [illegible]	3 [illegible]	3 35	3 39	3 43
	30	3 11	3 14	3 18	3 22	3 [illegible]	3 29	3 33
	40	3 2	3 [illegible]	3 9	3 12	3 16	3 19	3 23
	50	2 53	2 56	2 59	3 2	3 6	3 9	3 12
87	0	2 43	2 47	2 50	2 53	2 56	2 59	3 2
	10	2 34	2 37	2 40	2 43	2 46	2 49	2 52
	20	2 25	2 28	2 31	2 34	2 36	2 39	2 42
	30	2 16	2 19	2 21	2 24	2 27	2 29	2 32
	40	2 7	2 10	2 12	2 14	2 17	2 19	2 22
	50	1 58	2 0	2 3	2 5	2 7	2 9	2 12
88	0	1 49	1 51	1 53	1 55	1 57	1 59	2 2
	10	1 39	1 42	1 44	1 46	1 48	1 50	1 51
	20	1 31	1 33	1 34	1 36	1 38	1 40	1 41
	30	1 22	1 23	1 25	1 26	1 28	1 30	1 31
	40	1 13	1 14	1 15	1 17	1 18	1 20	1 21
	50	1 4	1 5	1 6	1 7	1 8	1 10	1 11
89	0	0 55	0 56	0 57	0 58	0 59	1 0	1 1
	10	0 45	0 46	0 47	0 48	0 49	0 50	0 51
	20	0 36	0 37	0 38	0 38	0 39	0 40	0 41
	30	0 27	0 27	0 28	0 28	0 29	0 30	0 30
	40	18	0 19	0 19	0 19	0 20	0 20	0 20
	50	0 9	0 9	0 9	0 10	0 10	0 10	0 10

TABLE VIII.

Parallax of the Moon less Refraction.

		Proportional parts for the parallax.										For the altitude.	
60'	61'	0"	1"	2"	3"	4"	5"	6"	7"	8"	9"		—
6' 10"	6' 17"	0	0	0	0	0	0	1	1	1	1	1'	1"
6 0	6 6	1	1	1	1	1	1	2	2	2	2	2	2
5 50	5 56	2	2	2	2	2	2	2	3	3	3	3	3
5 40	5 45	3	3	3	3	3	3	3	4	4	4	4	4
5 29	5 35	4	4	4	4	4	4	4	5	5	5	5	5
5 19	5 24	5	5	5	5	5	5	5	5	6	6	6	6
												7	7
5 9	5 14	0	0	0	0	0	0	0	1	1	1	8	8
4 59	5 4	1	1	1	1	1	1	1	1	1	1	9	9
4 48	4 53	2	2	2	2	2	2	2	2	2	2		
4 38	4 43	2	2	2	3	3	3	3	3	3	3		
4 28	4 32	3	3	3	3	3	4	4	4	4	4		
4 17	4 22	4	4	4	4	4	4	4	4	5	5		
4 7	4 11	0	0	0	0	0	0	0	0	0	1	1	1
3 57	4 1	1	1	1	1	1	1	1	1	1	1	2	2
3 47	3 50	1	1	1	1	1	2	2	2	2	2	3	3
3 36	3 40	2	2	2	2	2	2	2	2	2	2	4	4
3 26	3 29	2	3	3	3	3	3	3	3	3	3	5	5
3 16	3 19	3	3	3	3	3	3	3	3	4	4	6	6
												7	7
3 5	3 9	0	0	0	0	0	0	0	0	0	0	8	8
2 55	2 58	0	0	1	1	1	1	1	1	1	1	9	9
2 45	2 48	1	1	1	1	1	1	1	1	1	1		
2 35	2 37	1	1	1	1	1	2	2	2	2	2		
2 24	2 27	2	2	2	2	2	2	2	2	2	2		
2 14	2 16	2	2	2	2	2	2	2	2	3	3		
2 4	2 6	0	0	0	0	0	0	0	0	0	0	1	1
1 53	1 55	0	0	0	0	0	0	0	0	0	0	2	2
1 43	1 45	1	1	1	1	1	1	1	1	1	1	3	3
1 33	1 34	1	1	1	1	1	1	1	1	1	1	4	4
1 22	1 24	1	1	1	1	1	1	1	1	1	1	5	5
1 12	1 13	1	1	1	1	1	1	1	1	2	2	6	6
												7	7
1 2	1 3	0	0	0	0	0	0	0	0	0	0	8	8
0 52	0 52	0	0	0	0	0	0	0	0	0	0	9	9
0 41	0 42	0	0	0	0	0	0	0	0	0	0		
0 31	0 32	0	0	0	0	0	0	0	0	0	0		
0 21	0 21	0	0	0	0	0	0	0	0	0	0		
0 10	0 10	1	1	1	1	1	1	1	1	1	1		

TABLE IX.

Change in Altitude during the last Minute which precedes, and the first which follows the Sun's Passage over the Meridian.

Lat.	Declination of the same name as the latitude.												
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°
0°	[illegible]	56″·2	28″·1	1[illegible]·7	1[illegible]	[illegible]	9″·[illegible]	[illegible]·9	[illegible]	[illegible]″·0	5″·4	4″·9	4″·4
2	[illegible]	[illegible]	[illegible]·1	28·0	18·6	13·9	11·1	[illegible]	7·[illegible]	6·8	[illegible]·9	5·3	4·6
4	[illegible]	[illegible]·1	[illegible]	[illegible]5·8	[illegible]7·8	18·5	1[illegible]·9	11·[illegible]	[illegible]	7·7	6·7	5·9	[illegible]
6	[illegible]	[illegible]·0	[illegible]·8	[illegible]	55·[illegible]	[illegible]	18·3	13·6	10·8	8·9	7·6	6·6	[illegible]·5
8	14·0	15·[illegible]	2[illegible]·8	[illegible]·4	[illegible]	[illegible]	2[illegible]·3	18·1	1[illegible]·4	10·7	[illegible]	7·[illegible]	6·4
10	11·1	1[illegible]·9	15·5	2[illegible]	[illegible]·9	[illegible]	5[illegible]	[illegible]·9	17·[illegible]	1[illegible]·2	[illegible]·5	8·6	7·3
12	[illegible]·2	1[illegible]	1[illegible]·3	18·[illegible]	[illegible]7·3	[illegible]4·2	[illegible]	53·4	[illegible]	17·5	13·0	10·3	8·4
14	[illegible]	[illegible]·2	11·0	1[illegible]	[illegible]·1	26·9	5[illegible]·4	[illegible]	5[illegible]	[illegible]·0	17·1	1[illegible]·7	[illegible]·5
16	[illegible]·9	7·5	[illegible]·1	10·8	1[illegible]·1	17·[illegible]	2[illegible]	[illegible]	[illegible]	[illegible]1·4	[illegible]5·4	16·7	12·[illegible]
18	6·0	[illegible]·9	7·7	[illegible]·9	10·7	13·[illegible]	17·5	2[illegible]·0	[illegible]1·4	[illegible]	[illegible]0·3	24·8	16·4
20	5·[illegible]	6·0	6·[illegible]	7·[illegible]	8·8	10·[illegible]	13·0	17·1	2[illegible]·4	[illegible]·3	[illegible]	49·0	[illegible]·2
22	[illegible]·9	5·3	[illegible]·9	[illegible]	[illegible]	8·6	10·3	1[illegible]	1[illegible]·8	[illegible]4·8	[illegible]9·0	[illegible]	[illegible]7·7
24	[illegible]·4	4·8	[illegible]·2	5·[illegible]	[illegible]·4	7·3	8·[illegible]	10·0	1[illegible]·4	16·[illegible]	[illegible]4·[illegible]	[illegible]7·7	[illegible]
26	4·0	4·3	4·[illegible]	[illegible]·2	5·[illegible]	6·3	7·1	8·2	[illegible]·8	1[illegible]·1	1[illegible]·9	23·5	4[illegible]
28	[illegible]	4·0	4·[illegible]	[illegible]	[illegible]·0	5·5	[illegible]	6·9	6·0	[illegible]·5	11·7	15·4	22·7
30	3·[illegible]	3·[illegible]	3·0	[illegible]	[illegible]·5	4·9	5·[illegible]	6·0	6·8	7·8	9·[illegible]	11·3	14·9
32	3·1	[illegible]	[illegible]	[illegible]·8	4·1	4·4	4·8	5·2	5·8	6·[illegible]	7·[illegible]	[illegible]	10·9
34	2·9	3·1	[illegible]	[illegible]·5	3·7	[illegible]·0	4·3	[illegible]·6	5·[illegible]	5·[illegible]	6·[illegible]	7·3	8·5
36	[illegible]	2·[illegible]	[illegible]·0	3·2	3·4	[illegible]·6	3·8	4·1	[illegible]	[illegible]	[illegible]·4	6·1	7·0
38	[illegible]	2·[illegible]	[illegible]·8	2·9	3·0	3·2	3·[illegible]	[illegible]	[illegible]·0	4·[illegible]	4·7	[illegible]	6·0
40	[illegible]·3	[illegible]·4	2·6	[illegible]·7	2·8	3·0	3·1	3·1	3·[illegible]	[illegible]·8	4·1	4·[illegible]	5·0
42	[illegible]	[illegible]	2·[illegible]	2·[illegible]	[illegible]	2·7	2·9	[illegible]	3·1	[illegible]	[illegible]·6	4·0	[illegible]·3
44	[illegible]	[illegible]·1	[illegible]	2·[illegible]	2·[illegible]	[illegible]	2·6	[illegible]·7	2·9	[illegible]·1	3·3	3·5	3·6
46	[illegible]	[illegible]·0	2·0	2·1	[illegible]	[illegible]·3	[illegible]·4	[illegible]·5	2·[illegible]	[illegible]·6	3·0	3·1	[illegible]·3
48	1·[illegible]	1·8	1·[illegible]	2·0	[illegible]·0	[illegible]·1	[illegible]	2·3	2·[illegible]	2·[illegible]	[illegible]	2·[illegible]	3·0
50	1·[illegible]	1·[illegible]	1·[illegible]	1·[illegible]	1·9	1·[illegible]	2·0	2·1	[illegible]	2·3	[illegible]·4	2·5	2·6
52	1·[illegible]	1·[illegible]	1·6	1·[illegible]	1·7	[illegible]	1·8	1·9	2·0	[illegible]·1	2·1	[illegible]·2	2·4
54	1·[illegible]	[illegible]·5	1·5	1·6	1·[illegible]	1·[illegible]	1·7	1·[illegible]	1·8	1·9	2·0	2·0	[illegible]·1
56	1·[illegible]	1·4	1·4	1·[illegible]	1·[illegible]	[illegible]·5	1·[illegible]	1·6	1·6	1·7	[illegible]·8	1·8	1·[illegible]
58	1·2	1·[illegible]	1·3	1·3	1·4	1·4	1·4	1·[illegible]	1·[illegible]	1·[illegible]	1·[illegible]	1·7	1·7
60	1·1	1·2	1·2	1·[illegible]	1·2	1·[illegible]	1·3	1·3	1·4	1·4	1·4	1·[illegible]	1·5
62	1·0	1·1	1·1	1·1	[illegible]·1	[illegible]·2	1·2	1·2	1·[illegible]	1·3	1·3	1·3	1·4
64	1·0	1·0	1·0	1·0	1·0	1·1	1·1	1·1	1·1	1·1	1·[illegible]	1·[illegible]	1·[illegible]
66	0·9	0·[illegible]	0·[illegible]	0·9	0·9	1·0	1·0	1·0	1·0	1·0	1·0	1·1	1·1
68	0·8	0·8	0·8	0·8	0·8	0·9	[illegible]	0·9	0·9	0·9	0·9	1·0	1·0
70	0·7	0·7	0·7	0·7	0·8	0·8	0·8	0·8	0·8	0·9	0·8	0·9	0·9
72	0·6	0·7	0·7	0·7	0·7	0·7	0·7	0·7	0·7	0·7	0·7	0·7	0·8
74	0·6	0·6	0·6	0·6	0·6	0·[illegible]	0·6	0·6	0·6	0·6	0·6	0·7	0·7
76	[illegible]	0·[illegible]	0·5	0·5	0·5	0·5	0·5	0·5	0·[illegible]	0·5	0·6	0·6	0·6
78	[illegible]	0·[illegible]	0·4	0·[illegible]	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4

TABLE IX.

Change in Altitude during the last Minute which precedes, and the first which follows the Sun's Passage over the Meridian.

Latitude	Declination of the same name as the Latitude.												
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°
0°	[illegible]	56′·2	28″·1	18″·7	14·1	11′·1	9″·2	7′·[illegible]	6″·[illegible]	[illegible]′·0	5″·4	4″·9	4″·4
2	56″·2	28·2	18·7	1[illegible]·0	11·2	9·3	7·9	7·0	6·2	5·[illegible]	5·0	4·6	4·1
4	28″·1	18·7	14·0	11·2	[illegible]·3	8·0	7·0	6·2	5·[illegible]	[illegible]·0	4·[illegible]	4·1	3·8
6	18·7	14·0	11·2	9·[illegible]	[illegible]·0	6·9	6·1	5·5	4·[illegible]	4·[illegible]	4·[illegible]	[illegible]	[illegible]
8	14·0	[illegible]	9·3	8·0	7·0	6·2	5·6	[illegible]·0	4·6	4·2	3·[illegible]	3·[illegible]	[illegible]·4
10	11·1	9·3	8·0	7·0	6·2	5·6	5·0	[illegible]·6	4·2	3·9	3·6	3·4	3·[illegible]
12	9·2	7·9	7·0	[illegible]	[illegible]·6	5·1	[illegible]·6	[illegible]·3	3·9	3·7	3·[illegible]	3·2	3·0
14	7·9	6·9	6·1	[illegible]·5	5·1	4·6	4·2	3·9	3·7	3·4	3·2	3·0	2·8
16	6·9	6·1	[illegible]·5	[illegible]·0	4·6	4·[illegible]	3·9	3·7	3·4	[illegible]	3·0	2·9	2·7
18	6·0	5·5	4·9	4·[illegible]	4·2	3·9	3·6	3·4	3·2	[illegible]·0	2·9	2·7	2·6
20	5·4	4·9	4·5	4·2	3·9	[illegible]·6	3·4	3·2	[illegible]	2·9	2·7	2·6	2·4
22	4·[illegible]	4	4·2	3·9	[illegible]	[illegible]·4	[illegible]·2	3·0	[illegible]·9	[illegible]·7	2	2·4	2·[illegible]
24	4·4	[illegible]·1	[illegible]·8	3·[illegible]	[illegible]·4	3·[illegible]	3·0	2·8	2	[illegible]·6	2·[illegible]	2·4	2·2
26	4·0	[illegible]	3·[illegible]	[illegible]	[illegible]	3·0	2·9	2·7	2	2·4	2·3	2·2	2·1
28	[illegible]·7	3·[illegible]	[illegible]·3	[illegible]·1	[illegible]	2·8	2·6	2·5	2·4	2·3	2·[illegible]	2·1	2·0
30	3·4	3·2	[illegible]·0	2·[illegible]	2·7	2·6	2·5	2·[illegible]	2·[illegible]	2·[illegible]	2·1	2·0	2·0
32	3·1	[illegible]·0	2·9	2·[illegible]	[illegible]·6	2·[illegible]	2·4	2	[illegible]	[illegible]·1	2·[illegible]	1·9	1·8
34	2·9	[illegible]	[illegible]·6	2·5	[illegible]	2·3	[illegible]	2·[illegible]	2·[illegible]	2·0	1·9	1·8	1·[illegible]
36	2·7	2·6	2·5	2·4	[illegible]·3	2·2	2·1	2·0	1·9	1·[illegible]	1·8	1·7	1·7
38	2	[illegible]	2·3	2·[illegible]	2·1	2·1	2·0	1·9	1·8	1·[illegible]	1·7	1·7	1·6
40	2·[illegible]	2·[illegible]	2·[illegible]	2·1	2·[illegible]	2·0	1·9	1·8	1·9	1·[illegible]	1·[illegible]	1·6	1·[illegible]
42	2·2	2·1	2·0	[illegible]·0	[illegible]	1·9	1·8	1·7	1·7	1·[illegible]	1·[illegible]	1·5	1·5
44	2·0	1·9	1·9	1·8	1·8	1·7	1·7	[illegible]	1·6	[illegible]	[illegible]	1·4	1·4
46	1·[illegible]	1·8	1	1	1·7	1·[illegible]	1·[illegible]	1·[illegible]	1·5	1·[illegible]	1·[illegible]	1·4	1·[illegible]
48	1·8	1·7	1·7	1·[illegible]	1·6	1·[illegible]	1·3	1·[illegible]	1·4	[illegible]	1·[illegible]	1·3	1·[illegible]
50	1·[illegible]	1·[illegible]	1·6	1·[illegible]	1·5	1·4	1·4	1·[illegible]	1·3	[illegible]	1·3	1·2	1·2
52	1·[illegible]	1·5	1	1	1·[illegible]	1·4	1·[illegible]	1·3	1	[illegible]	1·[illegible]	1·2	1·1
54	1·[illegible]	1·[illegible]	1·4	1	1·[illegible]	1	1·2	1·2	1	[illegible]	1·[illegible]	1·1	1·1
56	1·3	1·3	1·3	1·[illegible]	1	1	1·[illegible]	1·1	1·1	1·1	1·1	1·0	1·0
58	1·2	1·[illegible]	1	1·[illegible]	1·1	1·1	1·1	1·1	1·0	[illegible]	[illegible]·0	1·0	1·0
60	1·1	1·1	1·1	1·[illegible]	1·1	1·[illegible]	1·0	1·0	1·0	1·[illegible]	0·9	0·9	0·9
62	1·0	1·0	1·0	1·[illegible]	1·[illegible]	1·[illegible]	[illegible]	0·9	[illegible]·9	0·9	0·[illegible]	0·9	0·9
64	1·0	0	[illegible]	0·9	0·9	0·[illegible]	0·[illegible]	0·[illegible]	0·8	[illegible]·8	[illegible]·8	0·8	0
66	0·9	0·9	0·[illegible]	0·[illegible]	0·8	0	0·8	0·[illegible]	0·8	0·[illegible]	0·8	0·7	
68	0·8	0	0·8	[illegible]	0·7	0·7	0·7	0·[illegible]	0·7	0·7	0·[illegible]		
70	0·7	0·[illegible]	0·7	0·[illegible]	0·[illegible]	0·[illegible]	0·[illegible]	0·7	0·7	0·6			
72	0·[illegible]	0·[illegible]	0·6	0·6	0·[illegible]	0·6	0·6	0·[illegible]	0·6				
74	0·6	0·[illegible]	0·[illegible]	0·5	0·5	0·5	0·[illegible]	0·5					
76	0·[illegible]	0·[illegible]	0·[illegible]	0·5	0·5	0·5	0·5						
78	0·4	0·[illegible]	0·[illegible]	[illegible]	0·[illegible]								

TABLE X.

Multipliers of the Numbers contained in TABLE IX.

	Interval between noon and the time of observation.								
	0′	1′	2′	3′	4′	5′	6′	7′	8′
0	0·0	1·0	4·0	9·0	16·0	25·0	36·0	49·0	64·0
2	0·0	1·0	4·1	9·2	16·2	25·3	36·4	49·5	64·5
4	0·0	1·1	4·3	9·4	16·5	25·7	36·8	49·9	65·1
6	0·0	1·2	4·4	9·6	16·8	26·0	37·2	50·4	65·6
8	0·0	1·3	4·6	9·8	17·1	26·3	37·6	50·9	66·1
10	0·0	1·4	4·7	10·0	17·4	26·7	38·0	51·4	66·7
12	0·0	1·4	4·8	10·2	17·6	27·0	38·4	51·9	67·2
14	0·1	1·5	5·0	10·4	17·9	27·4	38·8	52·3	67·8
16	0·1	1·6	5·1	10·7	18·2	27·7	39·3	52·8	68·3
18	0·1	1·7	5·3	10·9	18·5	28·1	39·7	53·3	68·9
20	0·1	1·8	5·4	11·1	18·8	28·4	40·1	53·8	69·4
22	0·1	1·9	5·6	11·3	19·1	28·8	40·5	54·3	70·0
24	0·2	2·0	5·8	11·6	19·4	29·2	41·0	54·8	70·6
26	0·2	2·1	5·9	11·8	19·7	29·5	41·4	55·3	71·1
28	0·2	2·2	6·1	12·0	19·9	29·9	41·8	55·8	71·7
30	0·3	2·3	6·3	12·3	20·3	30·3	42·3	56·3	72·3
32	0·3	2·4	6·4	12·5	20·5	30·6	42·7	56·7	72·8
34	0·3	2·5	6·6	12·7	20·8	31·0	43·1	57·3	73·4
36	0·4	2·6	6·8	13·0	21·2	31·4	43·6	57·8	74·0
38	0·4	2·7	6·9	13·2	21·5	31·7	44·0	58·3	74·5
40	0·4	2·8	7·1	13·4	21·8	32·1	44·4	58·8	75·1
42	0·5	2·9	7·3	13·7	22·1	32·5	44·9	59·3	75·7
44	0·5	3·0	7·5	13·9	22·4	32·9	45·3	59·8	76·3
46	0·6	3·1	7·7	14·2	22·7	33·3	45·8	60·3	76·8
48	0·6	3·2	7·8	14·4	23·0	33·6	46·2	60·8	77·4
50	0·7	3·4	8·0	14·7	23·4	34·0	46·7	61·4	78·0
52	0·8	3·5	8·2	15·0	23·7	34·4	47·2	61·9	78·6
54	0·8	3·6	8·4	15·2	24·0	34·8	47·6	62·4	79·2
56	0·9	3·7	8·6	15·5	24·3	35·2	48·1	62·9	79·8
58	0·9	3·9	8·8	15·7	24·7	35·6	48·5	63·5	80·4

TABLE XI.

Numbers for finding the Corrections of Longitude [illegible] Marine Chronometers.

Days elapsed since the chronometer was regulated.	Multiples of the second difference.	Days elapsed since the chronometer was regulated.	Multiples of the second difference.	Days elapsed since the chronometer was regulated.	Multiples of the second difference.	Days elapsed since the chronometer was regulated.	Multiples of the second difference.
1	1	31	496	61	1891	91	4186
2	3	32	528	62	1953	92	4278
3	6	33	561	63	2016	93	4371
4	10	34	595	64	2080	94	4465
5	15	35	630	65	2145	95	4560
6	21	36	666	66	2211	96	4656
7	28	37	703	67	2278	97	4753
8	36	38	741	68	2346	98	4851
9	45	39	780	69	2415	99	4950
10	55	40	820	70	2485	100	5050
11	66	41	861	71	2556	101	5151
12	78	42	903	72	2628	102	5253
13	91	43	946	73	2701	103	5356
14	105	44	990	74	2775	104	5460
15	120	45	1035	75	2850	105	5565
16	136	46	1081	76	2926	106	5671
17	153	47	1128	77	3003	107	5778
18	171	48	1176	78	3081	108	5886
19	190	49	1225	79	3160	109	5995
20	210	50	1275	80	3240	110	6105
21	231	51	1326	81	3321	111	6216
22	253	52	1378	82	3403	112	6328
23	276	53	1431	83	3486	113	6441
24	300	54	1485	84	3570	114	6555
25	325	55	1540	85	3655	115	6670
26	351	56	1596	86	3741	116	6786
27	378	57	1653	87	3828	117	6903
28	406	58	1711	88	3916	118	7021
29	435	59	1770	89	4005	119	7140
30	465	60	1830	90	4095	120	7260

TABLE XII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

FIRST TERM.

Altitude.	Latitude.										
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°
6°	1·00	1·00	1·01	1·01	1·02	1·02	1·02	1·03	1·03	1·03	1·04
8	1·00	1·01	1·01	1·02	1·02	1·03	1·03	1·04	1·04	1·05	1·05
10	1·00	1·01	1·01	1·02	1·03	1·03	1·04	1·04	1·05	1·06	1·06
12	1·00	1·01	1·02	1·02	1·03	1·04	1·05	1·05	1·06	1·07	1·08
14	1·00	1·01	1·02	1·03	1·04	1·04	1·05	1·06	1·07	1·08	1·09
16	1·00	1·01	1·02	1·03	1·04	1·05	1·06	1·07	1·08	1·09	1·10
18	1·00	1·01	1·02	1·03	1·05	1·06	1·07	1·08	1·09	1·11	1·12
20	1·00	1·01	1·03	1·04	1·05	1·06	1·08	1·09	1·10	1·12	1·13
22	1·00	1·01	1·03	1·04	1·06	1·07	1·09	1·10	1·12	1·13	1·15
24	1·00	1·02	1·03	1·05	1·06	1·08	1·10	1·11	1·13	1·15	1·16
26	1·00	1·02	1·03	1·05	1·07	1·09	1·10	1·12	1·14	1·16	1·18
28	1·00	1·02	1·04	1·06	1·08	1·09	1·11	1·13	1·15	1·17	1·19
30	1·00	1·02	1·04	1·06	1·08	1·10	1·12	1·14	1·17	1·19	1·21
32	1·00	1·02	1·04	1·07	1·09	1·11	1·13	1·16	1·18	1·20	1·23
34	1·00	1·02	1·05	1·07	1·10	1·12	1·14	1·17	1·19	1·22	1·25
36	1·00	1·03	1·05	1·08	1·10	1·13	1·15	1·18	1·21	1·24	1·26
38	1·00	1·03	1·06	1·08	1·11	1·14	1·17	1·20	1·22	1·25	1·28
40	1·00	1·03	1·06	1·09	1·12	1·15	1·18	1·21	1·24	1·27	1·31
42	1·00	1·03	1·06	1·10	1·13	1·16	1·19	1·23	1·26	1·29	1·33
44	1·00	1·03	1·07	1·10	1·14	1·17	1·21	1·24	1·28	1·31	1·35
46	1·00	1·04	1·07	1·11	1·15	1·18	1·22	1·26	1·30	1·34	1·38
48	1·00	1·04	1·08	1·12	1·16	1·20	1·24	1·28	1·32	1·36	1·40
50	1·00	1·04	1·08	1·13	1·17	1·21	1·25	1·30	1·34	1·39	1·43
52	1·00	1·05	1·09	1·14	1·18	1·23	1·27	1·32	1·37	1·42	1·47
54	1·00	1·05	1·10	1·15	1·19	1·24	1·29	1·34	1·40	1·45	1·50
56	1·00	1·05	1·10	1·16	1·21	1·26	1·32	1·37	1·43	1·48	1·54
58	1·00	1·06	1·11	1·17	1·2[illegible]	1·[illegible]	1·34	1·40	1·46	1·52	1·58
60	1·00	1·06	1·12	1·18	1·24	1·31	1·37	1·43	1·50	1·56	1·63
62	1·00	1·07	1·13	1·20	1·26	1·33	1·40	1·47	1·54	1·61	1·69
64	1·00	1·07	1·14	1·22	1·29	1·36	1·44	1·51	1·59	1·67	1·75
66	1·00	1·08	1·16	1·24	1·32	1·40	1·48	1·56	1·64	1·73	1·82
68	1·00	1·09	1·17	1·26	1·35	1·44	1·53	1·62	1·71	1·80	1·90
70	1·00	1·10	1·19	1·29	1·39	1·49	1·58	1·69	1·79	1·89	2·00
72	1·00	1·11	1·22	1·32	1·43	1·54	1·65	1·77	1·88	2·00	2·12
74	1·00	1·12	1·24	1·37	1·49	1·62	1·74	1·87	2·00	2·13	2·27
76	1·00	1·14	1·28	1·42	1·56	1·71	1·85	2·00	2·15	2·30	2·46
78	1·00	1·16	1·33	1·50	1·66	1·83	2·00	2·17	2·36	2·53	2·71
80	1·00	1·20	1·40	1·60	1·80	2·00	2·21	2·41	2·63	2·84	3·06
82	1·00	1·25	1·50	1·75	2·00	2·26	2·51	2·77	3·04	3·31	3·59
84	1·00	1·33	1·67	2·00	2·34	2·68	3·02	3·37	3·73	4·09	4·46

TABLE XII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

ARGUMENT.

Altitude.	Latitude.										
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°
6°	1·01	1·01	1·01	1·01	1·02	1·02	1·03	1·04	1·05	1·06	1·07
8	1·01	1·01	1·01	1·02	1·02	1·03	1·03	1·04	1·05	1·06	1·08
10	1·02	1·02	1·02	1·02	1·03	1·03	1·04	1·05	1·06	1·07	1·08
12	1·02	1·02	1·03	1·03	1·03	1·04	1·05	1·05	1·06	1·08	1·09
14	1·03	1·03	1·03	1·04	1·04	1·05	1·05	1·06	1·07	1·08	1·10
16	1·04	1·04	1·04	1·05	1·05	[illegible]	1·06	1·07	1·08	1·09	1·11
18	1·05	1·05	1·06	1·06	1·06	1·07	1·08	1·08	1·09	1·11	1·12
20	1·06	1·07	1·07	1·07	1·08	1·08	1·09	1·10	1·11	1·12	1·13
22	1·08	1·08	1·08	1·09	1·09	1·10	1·10	1·11	1·12	1·13	1·15
24	1·10	1·10	1·10	1·10	1·11	1·11	1·12	1·13	1·14	1·15	1·17
26	1·11	1·11	1·12	1·12	1·12	1·13	1·14	1·15	1·16	1·17	1·18
28	1·13	1·13	1·14	1·14	1·14	1·15	1·16	1·17	1·18	[illegible]	1·21
30	1·16	1·16	1·16	1·46	1·17	1·17	1·18	1·19	1·20	1·21	1·23
32	1·18	1·18	1·18	1·19	1·19	1·20	1·21	1·22	1·23	1·24	1·26
34	1·21	1·21	1·21	1·21	1·22	1·23	1·23	1·24	1·26	1·27	1·28
36	1·24	1·24	1·24	1·24	1·25	1·26	1·26	1·27	1·29	1·30	1·32
38	1·27	1·27	1·27	1·28	1·28	1·29	1·30	1·31	1·32	1·33	1·35
40	1·31	1·31	1·31	1·31	1·32	1·33	1·34	1·35	1·36	1·37	1·39
42	1·35	1·35	1·35	1·35	1·36	1·37	1·38	1·39	1·40	1·42	1·43
44	1·39	1·39	1·39	1·40	1·40	1·41	1·42	1·43	1·45	1·46	1·48
46	1·44	1·44	1·44	1·45	1·45	1·46	1·47	1·48	1·50	1·51	1·53
48	1·50	1·50	1·50	1·50	1·51	1·52	1·53	1·54	1·56	1·57	1·59
50	1·56	1·56	1·56	1·56	1·57	1·58	1·59	1·60	1·62	1·64	1·66
52	1·62	1·63	1·63	1·6[illegible]	1·64	1·65	1·66	1·67	1·69	1·71	1·73
54	1·70	1·70	1·71	1·71	1·72	1·73	1·74	1·75	1·77	1·79	1·81
56	1·79	1·79	1·79	1·80	1·81	1·82	1·83	1·84	1·86	1·88	1·90
58	1·89	1·89	1·89	1·90	1·91	1·92	1·93	1·95	1·96	1·98	2·01
60	2·00	2·00	2·01	2·01	2·02	2·03	2·05	2·06	2·08	2·10	2·13
62	2·13	2·13	2·13	2·14	2·15	2·16	2·18	2·20	2·22	2·24	2·27
64	2·28	2·28	2·29	2·29	2·30	2·32	2·33	2·35	2·37	2·40	2·43
66	2·46	2·46	2·47	2·47	2·48	2·50	2·51	2·53	2·56	2·59	2·62
68	2·67	2·67	2·68	2·68	2·70	2·71	2·73	2·75	2·78	2·81	2·84
70	2·92	2·93	2·93	2·94	2·95	2·97	2·99	3·01	3·04	3·07	3·11
72	3·24	3·24	3·24	3·25	3·27	3·29	3·31	3·34	3·37	3·40	3·44
74	3·63	3·63	3·64	3·65	3·66	3·68	3·71	3·74	3·77	3·82	3·86
76	4·13	4·14	4·14	4·16	4·17	4·20	4·23	4·26	4·30	4·35	4·40
78	4·81	4·81	4·82	4·84	4·86	4·88	4·92	4·96	5·00	5·06	5·12
80	5·76	5·76	5·77	5·79	5·82	5·85	5·89	5·94	5·99	6·06	6·13
82	7·19	7·19	7·20	7·23	7·26	7·30	7·35	7·41	7·48	7·56	7·65
84	9·57	9·57	9·59	9·62	9·66	9·72	9·78	9·86	9·95	10·06	10·18

TABLE XII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

FIRST TERM.

Altitude.	Latitude.										
	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°
6°	1·04	1·04	[illegible]	[illegible]	1·06	1·06	1·07	1·07	1·08	1·08	1·09
8	1·05	1·06	[illegible]	1·07	1·08	1·08	1·09	1·10	1·10	[illegible]	1·12
10	1·06	1·07	[illegible]	[illegible]	1·09	1·10	1·11	1·12	1·13	[illegible]	1·15
12	1·08	1·09	1·10	1·10	1·11	1·12	1·13	1·14	1·15	1·17	1·18
14	1·09	1·10	1·11	1·12	1·13	1·14	1·16	1·17	1·18	1·20	1·21
16	1·10	1·12	1·13	1·14	1·15	1·17	1·18	1·19	1·21	1·22	1·24
18	1·12	1·13	1·15	1·16	1·17	1·19	1·20	[illegible]	1·24	1·25	1·27
20	1·13	[illegible]	1·16	1·18	1·19	1·21	1·23	1·25	1·26	1·28	1·31
22	[illegible]	[illegible]	1·18	1·20	1·22	1·23	1·25	1·27	1·29	1·32	1·34
24	[illegible]	[illegible]	1·20	1·22	1·24	1·26	1·28	1·30	1·32	1·35	1·37
26	1·18	1·20	1·22	1·24	1·26	1·28	1·31	1·33	1·35	[illegible]	1·41
28	1·19	1·22	1·24	1·26	1·28	1·31	1·33	1·36	1·39	1·42	1·45
30	1·21	1·23	1·26	1·28	1·31	1·33	1·36	1·39	1·42	1·45	1·49
32	1·23	1·25	1·28	1·31	1·33	1·36	1·39	1·42	[illegible]	1·49	1·52
34	1·25	1·27	1·30	1·33	1·36	1·39	1·42	1·46	1·49	1·53	1·57
36	1·26	1·29	1·32	1·35	1·39	1·42	1·45	1·49	1·53	1·57	1·61
38	1·28	1·32	1·35	1·38	1·42	1·45	1·49	1·53	1·57	1·61	1·66
40	1·31	1·34	1·37	1·41	1·45	1·48	1·52	1·57	1·61	1·66	1·70
42	1·33	1·36	1·40	1·44	1·48	1·52	1·56	1·61	1·65	1·70	1·76
44	1·35	1·39	1·43	1·47	1·51	1·56	1·60	1·65	1·70	1·76	1·81
46	1·38	1·42	1·46	1·51	1·55	1·60	1·65	1·70	1·75	1·81	1·87
48	1·40	1·45	1·50	1·54	1·59	1·64	1·69	1·75	1·81	1·87	1·93
50	1·43	1·48	1·53	1·58	1·63	1·69	1·75	1·80	1·87	1·93	2·00
52	1·47	1·52	1·57	1·62	1·68	1·74	1·80	1·86	1·93	2·00	2·07
54	1·50	1·56	1·61	1·67	1·73	1·80	1·86	1·93	2·00	2·08	2·16
56	1·54	1·60	1·66	1·72	1·79	1·86	1·93	2·00	2·08	2·16	2·24
58	1·58	1·65	1·71	1·78	1·85	1·92	2·00	2·08	2·16	2·25	2·34
60	1·63	1·70	1·77	1·85	1·92	2·00	2·08	2·17	2·26	2·35	2·45
62	1·69	1·76	1·84	1·92	2·00	2·09	2·18	2·27	2·37	2·47	2·58
64	1·75	1·83	1·91	2·00	2·09	2·18	2·28	2·38	2·49	2·60	2·72
66	1·82	1·91	2·00	2·10	2·19	2·30	[illegible]	2·52	2·63	2·76	2·89
68	1·90	2·00	2·10	2·21	2·32	2·43	[illegible]	2·67	2·80	2·93	3·08
70	2·00	2·11	2·22	2·34	2·46	2·59	2·72	2·85	3·00	3·15	3·31
72	2·12	2·24	2·37	2·50	2·64	2·78	2·92	3·08	3·24	3·41	3·58
74	2·27	2·41	2·55	2·70	2·85	3·01	3·18	3·35	3·53	3·73	3·93
76	2·46	[illegible]	2·79	2·96	[illegible]	[illegible]	3·51	3·71	3·91	4·13	
78	2·71	2·90	3·10	3·30	[illegible]	3·72	3·94	4·17	4·42		
80	3·06	3·29	3·53	3·77	4·02	4·27	4·54	4·83			
82	3·59	3·88	4·17	4·47	4·78	5·11	5·45				
84	4·46	4·84	5·24	5·64	6·06	6·49					

TABLE XII.

For finding the Correction of the [illegible] of two Altitudes of the Sun taken out of the Meridian.

ARGUMENT.

Altitude.	Latitude.										
	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°
6°	1·07	1·09	1·10	1·12	1·14	1·16	[illegible]	[illegible]	1·24	1·28	1·31
8	1·08	1·09	1·11	1·12	1·14	1·17	1·19	[illegible]	1·25	1·28	1·32
10	[illegible]	1·10	1·11	1·13	1·15	1·17	1·20	[illegible]	1·26	1·29	1·33
12	1·09	1·10	1·12	1·14	1·16	1·18	1·21	1·23	1·26	1·30	1·34
14	1·10	1·11	1·13	1·15	1·17	1·19	1·22	1·24	1·27	1·31	1·35
16	1·11	1·12	1·14	1·16	1·18	1·20	1·23	1·26	1·29	1·32	1·36
18	1·12	1·13	1·15	1·17	1·19	1·21	1·24	1·27	1·30	1·33	1·37
20	1·13	1·15	1·17	1·18	1·21	1·23	1·26	1·28	[illegible]	1·35	1·39
22	1·15	1·16	1·18	1·20	1·22	1·25	1·27	1·30	[illegible]	[illegible]	1·41
24	1·17	1·18	1·20	1·22	1·24	1·26	1·29	1·32	[illegible]	[illegible]	1·43
26	1·18	1·20	1·22	1·24	1·26	1·29	1·31	1·34	1·38	1·41	1·45
28	1·21	1·22	1·24	1·26	1·28	1·31	1·34	1·37	1·40	1·44	1·48
30	1·23	1·25	1·26	1·29	1·31	1·33	1·36	1·39	[illegible]	[illegible]	1·51
32	1·26	1·27	1·29	1·31	1·34	1·36	1·39	1·42	[illegible]	1·50	1·54
34	1·28	1·30	1·32	1·34	1·37	1·39	1·42	1·46	1·49	1·53	1·58
36	1·32	1·33	1·35	1·38	1·40	1·43	1·46	1·49	1·53	1·57	1·61
38	1·35	1·37	1·39	1·41	1·44	1·47	1·50	1·53	1·57	1·61	1·66
40	1·39	1·41	1·43	1·45	1·48	1·51	1·54	1·58	1·61	1·66	1·70
42	1·43	1·45	1·47	1·50	1·52	1·55	1·59	1·62	1·66	1·71	1·76
44	1·48	1·50	1·52	1·55	1·58	1·61	1·64	1·68	1·72	1·76	1·82
46	1·53	1·55	1·58	1·60	1·63	1·66	1·70	1·74	1·78	1·83	1·88
48	1·59	1·61	1·64	1·66	1·69	1·73	1·76	1·80	1·85	1·90	1·95
50	1·66	1·68	1·70	1·73	1·76	1·80	[illegible]	1·88	1·92	1·97	2·03
52	1·73	1·75	1·78	1·81	1·84	1·88	1·92	1·96	2·01	2·06	2·12
54	1·81	1·84	1·86	1·89	1·93	1·97	2·01	2·05	2·10	2·16	2·22
56	1·90	1·93	1·96	1·99	2·03	2·07	2·11	2·16	2·21	2·27	2·34
58	2·01	2·04	2·07	2·10	2·14	2·18	2·23	2·28	2·33	2·40	2·46
60	2·13	2·16	2·19	2·23	2·27	2·31	2·36	2·41	2·47	2·54	2·61
62	2·27	2·30	2·33	2·37	2·41	2·46	2·51	2·57	2·63	2·70	2·78
64	2·43	2·46	2·50	2·54	2·58	2·63	2·69	2·75	2·82	2·90	2·98
66	2·62	2·65	2·69	[illegible]	2·79	2·84	2·90	2·97	3·04	3·12	3·21
68	2·84	2·88	2·92	[illegible]	3·02	3·08	3·15	3·22	3·30	3·39	3·49
70	3·11	3·15	3·20	3·25	3·31	3·38	3·45	3·53	3·61	3·71	3·82
72	3·41	3·49	3·54	3·60	3·67	3·71	3·81	3·90	4·00	4·11	4·22
74	3·86	3·91	3·97	4·04	4·11	4·19	4·28	4·38	4·48	4·60	4·74
76	4·40	4·46	4·53	4·60	4·68	4·77	4·87	4·99	5·11	5·25	
78	5·12	5·19	5·27	5·35	[illegible]	5·55	5·67	5·80	5·95		
80	6·13	6·21	6·30	6·41	6·52	[illegible]	6·79	6·95			
82	7·65	7·75	7·87	[illegible]	8·14	8·30	8·47				
84	10·18	10·32	10·47	10·64	10·84	11·05					

TABLE XII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

FIRST TERM.

Altitude.	Latitude.										
	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
6°	1·09	1·10	1·10	1·11	1·12	1·13	1·14	1·15	1·16	1·17	1·18
8	1·12	1·13	1·14	1·15	1·16	1·17	1·18	1·19	1·21	1·23	1·24
10	1·15	1·16	1·17	1·18	1·20	1·21	[illegible]	1·24	1·26	1·28	1·31
12	1·18	1·19	1·21	1·22	1·24	1·25	1·27	1·29	1·32	1·34	1·37
14	1·21	1·22	1·24	1·26	1·28	1·30	1·32	1·34	1·37	1·40	1·43
16	1·24	1·26	1·28	1·30	1·32	1·34	1·37	1·40	1·43	1·46	1·50
18	1·27	1·29	1·31	1·34	1·36	1·39	1·42	1·45	1·48	1·52	1·56
20	1·31	1·33	1·35	1·38	1·40	1·43	1·47	1·50	1·54	1·58	1·63
22	1·34	1·36	1·39	1·42	1·45	1·48	1·52	1·56	1·60	1·65	1·71
24	1·37	1·40	1·43	1·46	1·50	1·53	1·57	1·61	1·66	1·71	1·77
26	1·41	1·44	1·47	1·51	1·54	1·58	1·62	1·67	1·72	1·78	1·85
28	1·45	1·48	1·51	1·55	1·59	1·63	1·68	1·73	1·79	1·85	1·92
30	1·49	1·52	1·56	1·60	1·64	1·69	1·74	1·80	1·86	1·92	2·00
32	1·52	1·56	1·60	1·65	1·69	1·75	1·80	1·86	1·93	2·00	2·08
34	1·57	1·61	1·65	1·70	1·75	1·80	1·86	1·93	2·00	2·08	2·17
36	1·61	1·65	1·70	1·75	1·81	1·87	1·93	2·00	2·08	2·16	2·26
38	1·66	1·70	1·76	1·81	1·87	1·93	2·00	2·08	2·16	2·25	2·35
40	1·70	1·76	1·81	1·87	1·93	2·00	2·07	2·16	2·24	2·34	2·45
42	1·76	1·81	1·87	1·93	2·00	2·07	2·15	2·24	2·34	2·44	2·56
44	1·81	1·87	1·93	2·00	2·07	2·15	2·24	2·33	2·43	2·55	2·67
46	1·87	1·93	2·00	2·07	2·15	2·23	2·33	2·43	2·54	2·66	2·79
48	1·93	2·00	2·07	2·15	2·23	2·32	2·42	2·53	2·65	2·78	2·92
50	2·00	2·07	2·15	2·23	2·32	2·42	2·53	2·64	2·77	2·91	3·06
52	2·07	2·15	2·24	2·33	2·42	2·53	2·64	2·76	2·90	3·05	3·22
54	2·16	2·24	2·33	2·43	2·53	2·64	2·76	2·89	3·04	3·20	3·36
56	2·24	2·34	2·43	2·54	2·65	2·77	2·90	3·04	3·20	3·37	
58	2·34	2·44	2·55	2·66	2·78	2·91	3·05	3·20	3·37		
60	2·45	2·56	2·67	2·79	2·92	3·06	[illegible]	3·38			
62	2·58	2·69	2·82	2·95	3·09	3·24	3·41				
64	2·72	2·85	2·98	3·12	3·28	3·44					
66	2·89	3·02	3·17	3·33	3·50						
68	3·08	3·23	3·39	3·56							
70	3·31	3·47	3·65								
72	3·58	3·77									
74	3·93										

TABLE XII.

For finding the Correction of the [illegible] of two Altitudes of [illegible] Sun taken out of the Meridian.

ARGUMENT.

Altitude.	Latitude.										
	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
6°	1·31	1·35	1·40	1·45	1·50	1·56	1·63	1·71	1·80	1·90	2·01
8	1·32	1·36	1·40	1·45	1·51	1·57	1·64	1·72	1·81	1·91	2·02
10	1·33	1·37	1·41	1·46	1·52	1·58	1·65	1·73	1·82	1·92	2·03
12	1·34	1·38	1·42	1·47	1·53	1·59	1·66	1·74	1·83	1·93	2·05
14	1·35	1·39	1·43	1·48	1·54	1·60	1·67	1·75	1·84	1·95	2·06
16	1·36	1·40	1·45	1·50	1·56	1·62	1·69	1·77	1·86	1·96	2·08
18	1·37	1·42	1·46	1·51	1·57	1·64	1·71	1·79	1·88	1·98	2·10
20	1·39	1·43	1·48	1·53	1·59	1·66	1·73	1·81	1·90	2·01	2·13
22	1·41	1·45	1·50	1·55	1·61	1·68	1·75	1·84	1·93	2·04	2·16
24	1·43	1·47	1·52	1·58	1·64	1·70	1·78	1·86	1·96	2·07	2·19
26	1·45	1·50	1·55	1·60	1·66	1·73	1·81	1·89	1·99	2·10	2·23
28	1·48	1·52	1·58	1·63	1·69	1·76	1·84	1·93	2·03	2·14	2·27
30	1·51	1·55	1·61	1·66	1·73	1·80	1·88	1·97	2·07	2·18	2·31
32	1·54	1·59	1·64	1·70	1·76	1·84	1·9[illegible]	2·01	2·11	2·23	2·36
34	1·58	1·62	1·68	1·74	1·80	1·88	1·96	2·05	2·16	2·28	2·41
36	1·61	1·66	1·72	1·78	1·85	1·92	2·01	2·10	2·21	2·33	2·47
38	1·66	1·71	1·76	1·83	1·90	1·97	2·06	2·16	2·27	2·40	2·54
40	1·70	1·76	1·82	1·88	1·95	2·03	2·12	2·22	2·34	2·46	2·61
42	1·76	1·81	1·87	1·94	2·01	2·09	2·19	2·29	2·41	2·54	2·69
44	1·82	1·87	1·93	2·00	2·08	2·16	2·26	2·37	2·49	2·62	2·78
46	1·88	1·94	2·00	2·07	2·15	2·24	2·34	2·45	2·57	2·72	2·88
48	1·95	2·01	2·08	2·15	2·23	2·33	2·43	2·54	2·67	2·82	2·99
50	2·03	2·09	2·16	2·24	2·33	2·42	2·53	2·65	2·78	2·94	3·11
52	2·12	2·19	2·26	2·34	2·43	2·53	2·64	2·76	2·91	3·07	3·25
54	2·22	2·29	2·37	2·45	2·54	2·65	2·76	2·89	3·04	3·21	3·40
56	2·34	2·41	2·49	2·57	2·67	2·78	2·91	3·04	3·20	3·38	
58	2·46	2·54	2·62	[illegible]	2·82	2·94	3·07	3·21	3·38		
60	2·61	2·69	2·78	2·88	2·99	3·11	3·25	3·40			
62	2·78	2·87	2·96	3·07	3·18	3·31	3·46				
64	2·98	3·07	3·17	3·28	3·41	3·55					
66	3·21	3·31	3·42	3·54	3·67						
68	3·49	3·59	3·71	3·84							
70	3·82	3·93	4·07								
72	4·22	4·36									
74	4·73										

TABLE XII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

FIRST TERM.

Altitude.	Latitude.										
	60°	62°	64°	66°	68°	[illegible]	72°	74°	76°	78°	80°
6°	1·18	1·20	1·22	1·24	1·26	1·29	[illegible]	1·37	1·42	1·50	1·60
8	1·24	1·26	1·29	1·32	1·35	1·39	1·43	1·49	1·56	1·66	1·80
10	1·31	1·33	1·36	1·40	1·44	1·48	1·54	1·62	1·71	1·83	2·00
12	1·37	1·40	1·44	1·48	1·53	1·58	1·65	1·74	1·85	2·00	2·21
14	1·43	1·47	1·51	1·56	1·62	1·69	1·77	1·87	2·00	2·17	2·41
16	1·50	1·54	1·59	1·64	1·71	1·79	1·88	2·00	2·15	2·35	2·63
18	1·56	1·61	1·67	1·73	1·80	1·89	2·00	2·13	2·30	2·53	2·84
20	1·63	1·69	1·75	1·82	1·90	2·00	2·12	2·27	2·46	2·71	3·06
22	1·70	1·76	1·83	1·91	2·00	2·11	2·24	2·41	2·62	2·90	3·29
24	1·77	1·84	1·91	2·00	2·10	2·22	2·37	2·55	2·79	3·10	3·53
26	1·85	1·92	2·00	2·10	2·21	2·34	2·50	2·70	2·96	3·30	3·77
28	1·92	2·00	2·09	2·19	2·32	2·46	2·64	2·85	3·13	3·50	4·02
30	2·00	2·09	2·18	2·30	2·43	2·59	2·78	3·01	3·32	3·72	4·27
32	2·08	2·18	2·28	2·40	2·55	2·72	2·92	3·18	3·51	3·94	4·54
34	2·17	2·27	2·38	2·52	2·67	2·85	3·08	3·35	3·71	4·17	4·83
36	2·26	2·37	2·49	2·63	2·80	3·00	3·24	3·53	3·91	4·42	
38	2·35	2·47	2·60	2·76	2·94	3·15	3·41	3·72	4·13		
40	2·45	2·58	2·72	2·89	3·08	3·31	3·58	3·93			
42	2·56	2·69	2·85	3·02	3·23	3·47	3·77				
44	2·67	2·82	2·98	3·17	3·39	3·65					
46	2·79	2·95	3·12	3·33	3·56						
48	2·92	3·09	3·28	3·50							
50	3·06	3·24	3·44								
52	3·22	3·41									
54	3·38										

TABLE XII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

ARGUMENT.

Altitude.	Latitude.										
	60°	62°	64°	66°	68°	70°	72°	74°	76°	78°	80°
6°	2·01	2·14	2·29	2·47	2·68	2·94	3·25	3·65	4·16	4·84	5·79
8	2·02	2·15	2·30	2·48	2·70	2·95	3·27	3·66	4·17	4·86	5·82
10	2·03	2·16	2·32	2·50	2·71	2·97	3·29	3·68	4·20	4·88	5·85
12	2·05	2·18	2·33	2·51	2·73	2·99	3·31	3·71	4·23	4·92	5·89
14	2·06	2·20	2·35	2·53	2·75	3·01	3·34	3·74	4·26	4·96	5·94
16	2·08	2·22	2·37	2·56	2·78	3·04	3·37	3·77	4·30	5·00	5·99
18	2·10	2·24	2·40	2·59	2·81	3·07	3·40	3·82	4·35	5·06	6·06
20	2·13	2·27	2·43	2·62	2·84	3·11	3·44	3·86	4·40	5·12	6·13
22	2·16	2·30	2·46	2·65	2·88	3·15	3·49	3·91	4·46	5·19	6·21
24	2·19	2·33	2·50	2·69	2·92	3·20	3·54	3·97	4·53	5·27	6·30
26	2·23	2·37	2·54	2·74	2·97	3·25	3·60	4·04	4·60	5·35	6·41
28	2·27	2·41	2·58	2·79	3·02	3·31	3·67	4·11	4·68	5·45	6·52
30	2·31	2·46	2·63	2·84	3·08	3·38	3·74	4·19	4·77	5·55	6·65
32	2·36	2·51	2·69	2·90	3·15	3·45	3·82	4·28	4·87	5·67	6·79
34	2·41	2·57	2·75	2·97	3·22	3·53	3·90	4·38	4·99	5·80	6·95
36	2·47	2·63	2·82	3·04	3·30	3·61	4·00	4·48	5·11	5·95	
38	2·54	2·70	2·90	3·12	3·39	3·71	4·11	4·60	5·25		
40	2·61	2·78	2·98	3·21	3·49	3·82	4·23	4·74			
42	2·69	2·87	3·07	3·31	3·59	3·93	4·36				
44	2·78	2·96	3·17	3·42	3·71	4·07					
46	2·88	3·07	3·28	3·54	3·84						
48	2·99	3·18	3·41	3·67							
50	3·11	3·31	3·55								
52	3·25	3·46									
54	3·40										

TABLE XIII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

SECOND TERM.

Argument.	Declination of the same name as the latitude.												
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°
1·00	0·00	0·04	0·07	0·11	0·14	0·17	0·21	0·24	0·28	0·31	0·34	0·38	0·41
1·10	0·00	0·04	0·08	0·12	0·15	0·19	0·23	0·27	0·30	0·34	0·38	0·41	0·45
1·20	0·00	[illegible]	0·08	0·13	0·17	0·21	[illegible]	0·29	0·33	0·37	0·41	0·45	0·49
1·30	0·00	0·05	0·09	0·14	0·18	0·23	0·27	0·32	0·36	0·40	0·45	0·49	0·53
1·40	0·00	0·05	0·10	0·15	0·20	0·24	0·29	0·34	0·39	0·43	0·48	0·53	0·57
1·50	0·00	0·05	0·11	0·16	0·21	0·26	0·31	0·36	0·41	0·46	0·51	0·56	0·61
1·60	0·00	0·06	0·11	0·17	0·22	0·28	0·33	0·39	0·44	0·49	0·55	0·60	0·65
1·70	0·00	0·06	0·12	0·18	0·24	0·30	0·35	0·41	0·47	0·53	0·58	0·64	0·69
1·80	0·00	0·06	0·13	0·19	0·25	0·31	0·37	0·44	0·50	0·56	0·62	0·67	0·73
1·90	0·00	0·07	0·13	0·20	0·26	0·33	0·40	0·46	0·52	0·59	0·65	0·71	0·77
2·00	0·00	0·07	0·14	0·21	0·28	0·35	0·42	0·48	0·55	0·62	0·68	0·75	0·81
2·10	0·00	0·07	0·15	0·22	0·29	0·37	0·44	0·51	0·58	0·65	0·72	0·79	0·85
2·20	0·00	0·08	0·15	0·23	0·31	0·38	0·46	0·53	0·61	0·68	0·75	0·82	0·90
2·30	0·00	0·08	0·16	0·24	0·32	0·40	0·48	0·56	0·63	0·71	0·79	0·86	0·94
2·40	0·00	0·08	0·17	0·25	0·33	0·42	0·50	0·58	0·66	0·74	0·82	0·90	0·98
2·50	0·00	0·09	0·17	0·26	0·35	0·43	0·52	0·61	0·69	0·77	0·86	0·94	1·02
2·60	0·00	0·09	0·18	0·27	0·36	0·45	0·54	0·63	0·72	0·80	0·89	0·97	1·06
2·70	0·00	0·09	0·19	0·28	0·38	0·47	0·56	0·65	0·74	0.83	0·92	1·01	1·10
2·80	0·00	0·10	0·20	0·29	0·39	0·49	0·58	0·68	0·77	0·87	0·96	1·05	1·14
2·90	0·00	0·10	0·20	0·30	0·40	0·50	0·60	0·70	0·80	0·90	0·99	1·09	1·18
3·00	0·00	0·11	0·21	0·31	0·42	0·52	0·62	0·73	[illegible]	0·93	1·03	1·12	1·22
3·10	0·00	0·11	0·22	0·32	0·43	0·54	0·65	0·75	0·85	0·96	1·06	1·16	1·26
3·20	0·00	0·11	0·22	0·34	0·45	0·56	0·67	0·77	0·88	0·99	1·10	1·20	1·30
3·30	0·00	0·12	0·23	0·35	0·46	0·57	0·69	0·80	0·91	1·02	1·13	1·24	1·34
3·40	0·00	0·12	0·24	0·36	0·47	0·59	0·71	0·82	0·94	1·05	1·16	1·27	1·38
3·50	0·00	0·12	0·24	0·37	0·49	0·61	0·73	0·85	0·97	[illegible]	1·20	1·31	1·42
3·60	0·00	0·13	0·25	0·38	0·50	0·63	0·75	0·87	0·99	1·11	1·23	1·35	1·46
3·70	0·00	0·13	0·26	0·39	0·52	0·64	0·77	0·90	1·02	1·14	1·27	1·39	1·51
3·80	0·00	0·13	0·27	0·40	0·53	0·66	0·79	0·92	[illegible]	1·17	1·30	1·42	1·55
3·90	0·00	0·14	0·27	0·41	0·54	0·68	0·81	0·94	[illegible]	1·21	1·33	1·46	1·59
4·00	0·00	0·14	0·28	0·42	0·56	0·70	0·83	0·97	1·10	1·24	1·37	1·50	1·63
4·10	0·00	0·14	0·29	0·43	0·57	0·71	0·85	0·99	1·13	1·27	1·40	1·54	1·67
4·20	0·00	0·15	0·29	0·44	0·59	0·73	0·87	1·02	1·16	1·30	1·44	1·57	1·71
4·30	0·00	0·15	0·30	0·45	0·60	0·75	0·89	1·04	1·19	1·33	1·47	1·61	1·75
4·40	0·00	0·15	0·31	0·46	0·61	0·76	0·92	1·07	1·21	1·36	1·51	1·65	1·79
4·50	0·00	0·16	[illegible]	[illegible]	0·63	0·78	0·94	1·09	1·24	1·39	1·54	1·69	1·83

TABLE XIII.

For finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

SECOND TERM.

Argument.	Declination of the same name as the latitude.												
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°
4·50	0·00	[illegible]	0·31	0·47	0·63	[illegible]	0·94	1·09	1·24	1·39	[illegible]	1·69	1·83
4·60	0·00	[illegible]	0·32	0·48	[illegible]	[illegible]	0·96	1·11	1·27	1·42	[illegible]	1·72	1·87
4·70	0·00	0·16	0·33	0·49	0·65	0·82	0·98	1·14	1·30	1·45	1·61	1·76	1·91
4·80	0·00	0·17	0·34	0·50	0·67	0·83	1·00	1·16	1·32	1·48	1·64	1·80	1·95
4·90	0·00	0·17	0·34	0·51	[illegible]	0·85	1·02	1·19	1·35	1·51	1·68	1·84	1·99
5·00	0·00	0·18	0·35	[illegible]	0·70	0·87	1·04	1·21	1·38	1·55	1·71	1·87	2·03
5·10	0·00	0·18	0·36	0·53	0·71	0·89	1·06	1·23	1·41	1·58	1·74	1·91	2·07
5·20	0·00	0·18	0·36	0·54	0·72	0·90	1·08	1·26	1·43	1·61	1·78	1·95	2·12
5·30	0·00	0·19	0·37	0·55	0·74	0·92	1·10	1·28	1·46	1·64	1·81	1·99	2·16
5·40	0·00	0·19	0·38	0·56	0·75	0·94	1·12	1·31	1·49	1·67	1·85	2·02	2·20
5·50	0·00	0·19	0·38	0·58	0·77	0·96	1·14	1·33	1·52	1·70	1·88	2·06	2·24
5·60	0·00	0·20	0·39	0·59	0·78	0·97	1·16	1·36	1·54	1·73	1·92	2·10	2·28
5·70	0·00	0·20	0·40	0·60	0·79	0·99	1·19	1·38	1·57	1·76	1·95	2·14	2·32
5·80	0·00	0·20	0·41	0·61	0·81	1·01	1·21	1·40	1·60	1·79	1·98	2·17	2·36
5·90	0·00	0·21	0·41	0·62	0·82	1·02	1·23	1·43	1·63	1·82	2·02	[illegible]	2·40
6·00	0·00	0·21	0·42	0·63	0·84	1·04	1·25	1·45	1·65	1·85	2·05	2·25	2·44
6·10	0·00	0·21	0·43	0·64	0·85	1·06	1·27	1·48	1·68	1·89	2·09	2·29	2·48
6·20	0·00	0·22	0·43	0·65	0·86	1·08	1·29	1·50	1·71	1·92	2·12	2·32	2·52
6·30	0·00	0·22	0·44	0·66	0·88	1·09	1·31	1·52	1·74	1·95	2·16	2·36	2·56
6·40	0·00	0·22	0·45	[illegible]	0·89	1·11	1·33	1·55	1·76	1·98	2·19	2·40	2·60
6·50	0·00	0·23	0·45	0·68	0·91	1·13	1·35	1·57	1·79	2·01	2·22	2·44	2·64
6·60	0·00	0·23	0·46	0·69	0·92	1·15	1·37	1·60	1·82	2·04	2·26	2·47	2·68
6·70	0·00	0·23	0·47	0·70	0·93	1·16	1·39	1·62	1·85	2·07	2·29	2·51	2·73
6·80	0·00	0·24	0·47	0·71	0·95	1·18	1·41	1·65	1·87	2·10	2·33	2·55	2·77
6·90	0·00	0·24	0·48	0·72	0·96	1·20	1·44	1·67	1·90	2·13	2·36	2·59	2·81
7·00	0·00	0·24	0·49	0·73	0·97	1·22	1·46	1·69	1·93	2·16	2·39	2·62	2·85
7·10	0·00	0·25	0·50	0·74	0·99	1·23	1·48	1·72	1·96	2·19	2·43	2·66	2·89
7·20	0·00	0·25	0·50	0·75	1·00	1·25	1·50	1·74	1·99	2·23	2·46	2·70	2·93
7·30	0·00	0·26	0·51	0·76	1·02	1·27	1·52	1·77	2·01	2·26	2·50	2·74	2·97
7·40	0·00	0·26	0·52	0·77	1·03	1·29	1·54	1·79	2·04	2·29	2·53	2·77	3·01
7·50	0·00	0·26	0·52	0·78	1·04	1·30	1·56	1·81	2·07	2·32	2·57	2·81	3·05
7·60	0·00	0·27	0·53	0·79	1·06	[illegible]	[illegible]	[illegible]	[illegible]	2·35	2·60	2·85	3·09
7·70	0·00	0·27	0·54	0·81	1·07	1·34	1·60	1·86	[illegible]	2·38	2·63	2·88	3·13
7·80	0·00	0·27	0·54	0·82	1·09	1·35	1·62	1·89	2·15	2·41	2·67	2·92	3·17
7·90	0·00	0·28	0·55	0·83	1·10	1·37	1·64	1·91	[illegible]	[illegible]	2·70	2·96	3·21
8·00	0·00	0·28	0·56	0·84	1·11	1·39	1·66	1·94	2·21	2·47	2·74	3·00	3·25

TABLE XIII.

To finding the Correction of the less of two Altitudes of the Sun taken out of the Meridian.

SECOND TERM.

Argument.	Declination of a different name from the latitude.												
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°
1·00	2·00	1·97	1·93	1·90	1·86	1·83	1·79	1·76	1·72	1·69	1·66	1·63	1·59
1·10	2·00	1·96	1·92	1·89	1·85	1·81	[illegible]	1·73	1·70	1·66	1·62	1·59	1·55
1·20	2·00	1·96	1·92	1·88	1·83	1·79	1·75	1·71	1·67	1·63	1·59	1·55	1·51
1·30	2·00	1·96	1·91	1·86	1·82	1·77	1·73	1·69	1·64	1·60	1·56	1·51	1·47
1·40	2·00	1·95	1·90	1·85	1·81	1·76	1·71	1·66	1·61	1·57	1·52	1·48	1·43
1·50	2·00	1·95	1·90	1·84	1·79	1·74	1·69	1·64	1·59	1·54	1·49	1·44	1·39
1·60	2·00	1·94	1·89	1·83	1·78	1·72	1·67	1·61	1·56	1·51	1·45	1·40	1·35
1·70	2·00	1·94	1·88	1·82	1·76	1·71	1·65	1·59	1·53	1·48	1·42	1·36	1·31
1·80	2·00	1·94	1·87	1·82	1·75	1·69	1·63	1·56	1·50	1·44	1·38	[illegible]	1·27
1·90	2·00	1·93	1·87	1·80	1·74	1·67	1·61	1·54	1·48	1·41	1·35	1·29	1·23
2·00	2·00	1·93	1·86	1·79	1·72	1·65	1·58	1·52	1·45	1·38	1·32	1·25	1·19
2·10	2·00	1·93	1·85	1·78	1·71	1·64	1·56	1·49	1·42	1·35	1·28	1·21	1·15
2·20	2·00	1·92	1·65	1·77	1·69	1·62	1·54	1·47	1·39	1·32	1·25	1·18	1·11
2·30	2·00	1·92	1·84	1·76	1·68	1·60	1·52	1·44	1·37	1·29	1·21	1·14	1·07
2·40	2·00	1·92	1·83	1·75	1·67	1·58	1·50	1·42	1·34	1·26	1·18	1·10	1·02
2·50	2·00	1·91	1·83	1·74	1·65	1·57	1·48	1·40	1·31	1·23	1·15	1·06	0·98
2·60	2·00	1·91	1·82	1·73	1·64	1·55	1·46	1·37	1·28	1·20	1·11	1·03	
2·70	2·00	1·91	1·81	1·72	1·62	1·53	1·44	1·35	1·26	1·17	1·08	0·99	
2·80	2·00	1·90	1·81	1·71	1·61	1·51	1·42	1·32	1·23	1·14	1·04		
2·90	2·00	1·90	1·80	1·70	1·60	1·50	1·40	1·30	1·20	1·10	1·01		
3·00	2·00	1·90	1·79	1·69	1·38	1·48	1·38	1·27	[illegible]	1·07	0·97		
3·10	2·00	1·89	1·78	1·68	1·57	1·46	1·36	1·25	1·15	1·04			
3·20	2·00	1·89	1·78	1·67	1·56	1·44	1·34	1·23	1·12	1·01			
3·30	2·00	1·89	1·77	1·66	[illegible]	1·43	1·31	1·20	1·09	0·98			
3·40	2·00	1·88	1·76	1·65	1·53	[illegible]	1·29	1·18	1·06				
3·50	2·00	1·88	1·76	1·63	1·51	1·39	1·27	1·15	[illegible]				
3·60	2·00	1·87	1·75	1·62	1·50	[illegible]	1·25	1·13	1·01				
3·70	2·00	1·87	1·74	1·61	1·49	1·36	1·23	1·11	0·98				
4·80	2·00	1·87	1·74	1·60	1·47	1·34	1·21	1·08					
3·90	2·00	1·86	1·73	1·59	1·46	1·32	1·19	1·06					
4·00	2·00	1·86	1·72	1·58	[illegible]	1·31	1·17	1·03					
4·10	2·00	1·86	1·71	1·57	1·43	1·29	1·15	1·01					
4·20	2·00	1·85	1·71	[illegible]	1·42	1·27	1·13	0·98					
4·30	2·00	1·85	1·70	[illegible]	1·40	1·25	1·11						
4·40	2·00	1·85	1·69	1·54	1·39	1·24	1·09						
4·50	2·00	1·84	1·69	1·53	1·37	1·22	1·06						

TABLE XIII.

For finding the Correction of the [illegible] of two Altitudes of the Sun taken out of the Meridian.

SECOND TERM.

Argument.	Declination of a different n[illegible] the latitude.											
	0°	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°
4·50	2·00	[illegible]	1·69	1·53	1·37	1·22	1·06						
4·60	2·00	1·84	1·68	1·52	1·36	1·20	1·04						
4·70	2·00	1·84	1·67	1·51	1·35	1·18	1·02						
4·80	2·00	1·83	1·67	1·50	1·33	1·17	1·00						
4·90	2·00	1·83	1·66	1·49	1·32	1·15							
5·00	2·00	1·83	1·65	1·48	1·30	1·13							
5·10	2·00	1·82	1·64	1·47	1·29	1·11							
5·20	2·00	1·82	1·64	1·46	1·28	1·10							
5·30	2·00	1·82	1·63	1·45	1·26	1·08							
5·40	2·00	1·81	1·62	1·44	1·25	1·06							
5·50	2·00	1·81	1·62	1·43	[illegible]	1·05							
5·60	2·00	1·80	1·61	1·42	1·22	1·03							
5·70	2·00	1·80	1·60	1·40	1·21	1·01							
5·80	2·00	1·80	1·60	1·39	1·19	0·99							
5·90	2·00	1·79	1·59	1·38	1·18								
6·00	2·00	1·79	1·58	1·37	1·17								
6·10	2·00	1·79	1·57	1·36	1·15								
6·20	2·00	1·78	1·57	1·35	1·14								
6·30	2·00	1·78	1·56	1·34	1·12								
6·40	2·00	1·78	1·55	1·33	1·11								
6·50	2·00	1·77	[illegible]	1·32	1·10								
6·60	2·00	1·77	1·54	1·31	1·08								
6·70	2·00	1·77	1·53	1·30	1·07								
6·80	2·00	1·76	1·53	1·29	1·05								
6·90	2·00	1·76	1·52	1·28	1·04								
7·00	2·00	1·76	1·51	1·27	1·03								
7·10	2·00	1·75	1·51	1·26	1·01								
7·20	2·00	1·75	1·50	1·25	1·00								
7·30	2·00	1·75	1·49	1·24									
7·40	2·00	1·74	1·48	1·23									
7·50	2·00	1·74	[illegible]	1·22									
7·60	2·00	1·74	1·47	1·21									
7·70	2·00	1·73	1·46	1·20									
7·80	2·00	1·73	1·46	1·19									
7·90	2·00	1·72	1·45	1·17									
8·00	2·00	1·72	1·44	1·16									

TABLE XIV.

Azimuth corresponding to the Way made in Latitude.

Azimuth.	Multiplier.	Azimuth.	Multiplier.	Azimuth.	Multiplier.	Azimuth.	Multiplier.	Azimuth.	Multiplier.	Azimuth.	Multiplier.
0°	0·00	30°	0·13	60°	0·50	90°	1·00	120°	1·50	150°	1·87
1	0·00	31	0·14	61	0·52	91	1·02	121	1·52	151	1·88
2	0·00	32	0·15	62	0·53	92	1·04	122	1·53	152	1·88
3	0·00	33	0·16	63	0·55	93	1·05	123	1·55	153	1·89
4	0·00	34	0·17	64	0·56	94	1·07	124	1·56	154	1·90
5	0·00	35	0·18	65	0·58	95	1·09	125	1·57	155	1·91
6	0·01	36	0·19	66	0·59	96	1·11	126	1·59	156	1·91
7	0·01	37	0·20	67	0·61	97	1·12	127	1·60	157	1·92
8	0·01	38	0·21	68	0·63	98	1·14	128	1·62	158	1·93
9	0·01	39	0·22	69	0·64	99	1·16	129	1·63	159	1·93
10	0·02	40	0·23	70	0·66	100	1·17	130	1·64	160	1·94
11	0·02	41	0·25	71	0·67	101	1·19	131	1·66	161	1·95
12	0·02	42	0·26	72	0·69	102	1·21	132	1·67	162	1·95
13	0·03	43	0·27	73	0·71	103	1·23	133	1·68	163	1·96
14	0·03	44	0·28	74	0·72	104	1·24	134	1·70	164	1·96
15	0·03	45	0·29	75	0·74	105	1·26	135	1·71	165	1·97
16	0·04	46	0·31	76	0·76	106	1·28	136	1·72	166	1·97
17	0·04	47	0·32	77	0·78	107	1·29	137	1·73	167	1·97
18	0·05	48	0·33	78	0·79	108	1·31	138	1·74	168	1·98
19	0·06	49	0·34	79	0·81	109	1·33	139	1·76	169	1·98
20	0·06	50	0·36	80	0·83	110	1·34	140	1·77	170	1·99
21	0·07	51	0·37	81	0·84	111	1·36	141	1·78	171	1·99
22	0·07	52	0·38	82	0·86	112	1·38	142	1·79	172	1·99
23	0·08	53	0·40	83	0·88	113	1·39	143	1·80	173	1·99
24	0·09	54	0·41	84	0·90	114	1·41	144	1·81	174	2·00
25	0·09	55	0·43	85	0·91	115	1·42	145	1·82	175	2·00
26	0·10	56	0·44	86	0·93	116	1·44	146	1·83	176	2·00
27	0·11	57	0·46	87	0·95	117	1·45	147	1·84	177	2·00
28	0·12	58	0·47	88	0·97	118	1·47	148	1·85	178	2·00
29	0·13	59	0·49	89	0·98	119	1·49	149	1·86	179	2·00
30	0·13	60	0·50	90	1·00	120	1·50	150	1·87	180	2·00

TABLE XV.

Altitude of the Sun at the Instant of his passing the prime vertical, or at that of his greatest Azimuth.

Latitude.	Declination of the same name as the latitude.													
	0°		2°		4°		6°		8°		10°		12°	
0°	0°	0′	0°	0′	0°	0′	0°	[illegible]	[illegible]	0′	0°	0′	0°	0′
2	0	0	90	0	30	1	[illegible]	30	14	31	11	36	9	40
4	0	0	30	1	90	[illegible]	41	52	30	5	23	41	19	36
6	0	0	19	30	41	[illegible]	90	0	48	40	40	9	30	11
8	0	0	14	31	30	5	48	41	90	0	53	[illegible]	42	1
10	0	0	11	35	23	41	37	0	53	17	90	0	56	38
12	0	0	9	40	19	36	30	11	42	2	56	39	90	0
14	0	0	8	18	16	45	25	36	35	7	45	53	59	15
16	0	0	7	16	14	40	22	17	30	20	39	4	48	59
18	0	0	6	29	13	3	19	46	26	46	34	11	42	17
20	0	0	5	51	11	46	17	48	24	1	30	31	37	27
22	0	0	5	21	10	44	16	12	21	49	27	37	33	43
24	0	0	4	55	9	53	14	53	20	1	25	17	30	45
26	0	0	4	34	9	9	13	48	18	31	23	21	28	19
28	0	0	4	16	8	33	12	52	17	15	21	43	26	17
30	0	0	4	0	8	1	12	4	16	10	20	19	24	34
32	0	0	3	52	7	34	11	23	15	14	19	8	23	6
34	0	0	3	35	7	10	10	46	14	25	18	8	21	50
36	0	0	3	24	6	49	10	15	13	42	17	11	20	43
38	0	0	3	15	6	31	9	47	13	4	16	23	19	44
40	0	0	3	7	6	14	9	21	12	30	15	40	18	52
42	0	0	2	59	5	59	8	59	11	59	15	3	18	6
44	0	0	2	53	5	46	8	39	11	33	14	29	17	25
46	0	0	2	47	5	34	8	21	11	10	13	58	16	48
48	0	0	2	41	5	23	8	5	10	48	13	31	16	15
50	0	0	2	36	5	13	7	50	10	28	13	6	15	45
52	0	0	2	32	5	5	7	37	10	11	12	44	15	18
54	0	0	2	28	4	57	7	25	9	54	12	[illegible]	14	53
56	0	0	2	25	4	50	7	14	9	40	12	6	14	32
58	0	0	2	22	4	43	7	4	9	27	11	49	14	12
60	0	0	2	19	4	37	6	56	9	15	11	34	13	54
62	0	0	[illegible]	16	4	31	6	48	9	4	11	21	13	37
64	0	0	[illegible]	14	4	27	6	41	8	53	11	9	13	25
66	0	0	[illegible]	12	4	22	6	34	8	44	10	58	13	10
68	0	0	2	9	4	19	6	28	8	37	10	48	12	58
70	0	0	2	8	4	13	6	[illegible]	8	31	10	39	12	[illegible]
72	0	0	2	6	4	12	6	19	8	25	10	31	12	[illegible]
74	0	0	2	5	4	9	6	15	8	20	10	25	12	30
76	0	0	2	4	4	7	6	11	8	15	10	19	12	23
80	0	0	2	2	4	4	6	5	8	8	10	10	12	11

TABLE XV.

Altitude of the Sun at the Instant of his passing the prime vertical, or at that of his greatest Azimuth.

Latitude.	Declination of the same name as the latitude.													
	12°		14°		16°		18°		20°		22°		24°	
0°	0°	0′	0°	0′	0°	0′	0°	0′	0°	0′	0°	0′	0°	0′
2	9	40	8	18	7	[illegible]	6	29	5	52	5	24	4	55
4	19	36	16	45	14	[illegible]	13	3	9	20	10	43	9	53
6	30	11	25	36	22	17	19	46	17	48	16	12	14	38
8	[illegible]	1	35	7	30	20	26	46	24	1	21	48	20	1
10	56	38	45	52	39	8	34	11	30	30	27	37	25	16
12	90	0	59	15	48	58	42	17	37	26	33	42	30	44
14	59	15	90	0	61	22	51	36	45	1	40	13	36	30
16	48	59	61	23	90	0	63	6	50	12	47	22	42	39
18	42	17	51	32	63	8	90	0	64	37	55	[illegible]	49	26
20	37	27	45	2	53	43	64	40	90	0	65	[illegible]	57	13
22	33	43	40	14	47	22	55	35	65	56	90	0	67	5
24	30	45	36	30	42	40	49	27	57	15	67	6	90	0
26	28	19	33	30	38	58	44	50	51	18	58	44	68	7
28	26	17	31	1	35	57	41	10	46	47	52	57	60	3
30	24	34	28	56	33	57	38	11	43	10	48	32	54	26
32	23	6	27	10	31	20	35	41	40	12	45	0	50	8
34	21	50	25	38	29	32	33	53	37	43	42	[illegible]	46	40
36	20	43	24	18	27	58	31	43	35	35	39	[illegible]	43	48
38	19	44	23	9	26	30	30	8	33	45	37	29	41	22
40	18	52	22	7	25	24	28	44	32	9	35	39	39	15
42	18	6	21	12	24	20	27	30	30	45	34	3	37	26
44	17	25	20	23	23	23	26	25	29	30	32	38	35	50
46	16	48	19	39	22	32	25	27	28	24	31	23	34	26
48	16	15	19	0	21	46	24	34	27	27	30	16	33	11
50	15	45	18	25	21	5	23	48	26	32	29	17	32	4
52	15	18	17	53	20	29	23	6	25	44	28	23	31	5
54	14	53	17	24	19	[illegible]	22	28	25	1	27	[illegible]	30	11
56	14	32	16	58	19	[illegible]	21	53	24	22	26	52	29	23
58	14	12	16	35	18	58	21	22	23	47	26	13	28	40
60	13	54	16	13	18	33	20	54	23	16	25	38	28	1
62	13	37	15	54	18	12	20	30	22	48	25	7	27	26
64	13	23	15	37	17	53	20	7	22	[illegible]	24	38	26	54
66	13	10	15	22	17	34	19	46	22	0	24	13	26	26
68	12	58	15	8	17	18	19	28	21	39	23	50	26	1
70	12	47	14	45	17	3	19	12	21	21	23	30	25	39
72	12	38	14	44	16	51	18	54	21	5	23	12	25	19
74	12	30	14	35	16	40	18	45	20	51	22	56	25	2
76	12	23	14	27	16	30	18	34	20	39	22	43	24	47
80	12	11	14	14	16	15	18	17	20	20	22	22	24	24

TABLE XVI.

Right Ascensions and Declinations of thirty-six of the principal fixed Stars, for the 1st of January, 1815, with their Annual Variations.

Names and characters.		Right ascension in sidereal time.			Annual variation.	Declination.			Annual variation.
	Mag.	h.	m.	s.	s. +	°	′	″	s.
γ Pegasi	2	0	3	43·02	3·069	14	9	26·70 N.	+ 20·20
α Arietis......	2.3	1	56	45·78	3·347	22	35	1·91 N.	+ 17 47
α Ceti	2	2	52	36·91	3·115	3	21	35·15 N.	+ 14·75
Aldebaran ..	1	4	25	18·84	3·426	16	7	43·40 N.	+ 8·00
Capella	1	5	3	2·35	4 415	45	47	47·01 N.	+ 4·57
Rigel	1	5	55	39·00	2·876	8	25	15·04 S.	− 4·92
β Tauri	2	5	14	36·20	3·781	28	[illegible]	27·73 N.	+ 3·91
α Orionis	1	5	45	9·42	3·243	7	21	51·57 N.	+ 1·49
Sirius	1	6	36	59·94	2·653	16	27	59·43 S.	+ 4·21
Castor......	2	7	22	46·60	3·853	32	17	0·22 N.	− 7·06
Procyon	1.2	7	29	36·45	3·142	5	41	34·71 N.	− 8·53
Pollux......	2	7	33	58·6[illegible]	3 688	28	27	51·21 N.	− 7·93
α Hydræ......	2	9	18	29·60	2·946	7	51	35·60 S.	− 15·10
Regulus	1	9	58	30·56	3·212	12	52	7·03 N.	− 17·19
β Leonis......	1.2	11	39	36·74	3·067	15	36	24·88 N.	− 20·04
β Virginis	3	11	41	3·39	3·125	2	46	30·44 N.	− 20·22
α Virginis	1	13	15	27·61	3·147	10	11	19 00 S.	+ 18·80
Arcturus....	1	14	7	13·38	2·728	20	9	10·39 N.	− 18·79
[1] α Libræ	2	14	40	28·33	3·296	15	12	59·37 S.	+ 15·19
[2] α Libræ	2	14	40	39·66	3·297	15	15	43·73 S.	+ 15·21
α Coronæ	2.3	15	26	51·53	2·545	27	20	42·13 N.	− 12·49
α Serpentis....	2	15	35	9·67	2·945	7	1	3·30 N.	− 11·70
Antares	1	16	18	4·98	3·658	26	0	20·79 S.	+ 8·43
α Hercules	2.3	17	6	12·91	2·781	14	36	46·16 N.	− 4·48
α Ophiuchi....	2	17	26	20·90	2·776	12	42	20·61 N.	− 3·03
α Lyræ	1	18	30	40 32	2·027	38	37	2·53 N.	+ 2·91
γ Aquilæ	3	19	37	27·53	2·646	10	10	22·14 N.	+ 8·38
α Aquilæ	1.2	19	41	45·15	2·925	8	23	24·63 N.	+ 9·11
β Aquilæ	3.4	19	46	13·34	2·944	5	57	18·41 N.	+ 8·57
[1] α Capricorni ..	4	20	7	23·05	3·336	13	4	2·50 S.	− 10·80
[2] α Capricorni ..	3	20	7	46·89	3·339	13	6	21·07 S.	− 10·81
α Cigni	1.2	20	35	7·40	2·038	44	37	26 88 N.	+ 12 56
α Aquarii	3	21	56	16·48	3·081	1	12	39·42 S.	− 17·36
Fomalhaut ..	1.2	22	47	24·27	3·343	30	35	44·40 S.	− 19·[illegible]
α Pegasi......	2	22	55	32·88	2·973	14	12	54·39 N.	+ 19·43
α Andromedæ	2	23	58	50·52	3·070	28	4	14·07 N.	+ 19·99

TABLE XVII.

Logarithms of Numbers and their Complements from 1 to 3500.

When the given number contains integer places, let the number of those places be denoted by n, then the

Index of the log. $= n - 1$; and, n being less than 11 (which it is in all common cases), the index of the comp. log. $= 10 - n$; except when the given number is 10, 100, 1000, &c. and then it is $11 - n$.

And when the given number consists wholly of decimals, let d denote the number of places which the first efficient figure is from the decimal point, then the

Index of the log. $= - d$ and the index of comp. log. $= 9 + d$.

Note.—From the places where the points occur in the logarithms, and the first figures of the numbers change from 0 to 9, in the complements, the two common figures in the next line are to be taken.

N.	Log.	Comp. log.	N.	Log.	Comp. log.	N.	Log.	Comp. log.
1	0·00000	10·00000	34	1·53148	8·46852	67	1·82607	8·17393
2	0·30103	9·69897	35	1·54407	8·45593	68	1·83251	8·16749
3	0·47712	9·52288	36	1·55630	8·44370	69	1·63885	8·16115
4	0·60206	9·39794	37	1·56820	8·43180	70	1·84510	8·15490
5	0·69897	9·30103	38	1·57978	8·42022	71	1·85126	8·14874
6	0·77815	9·22185	39	1·59106	8·40894	72	1·85733	8·14267
7	0·84510	9·15490	40	1·60206	8·39794	73	1·86332	8·13668
8	0·90309	9·09691	41	1·61278	8·38722	74	1·86923	8·13077
9	0·95424	9·04576	42	1·62325	8·37675	75	1·87506	8·12494
10	1·00000	9·00000	43	1·63347	8·36653	76	1·88081	8·11919
11	1·04139	8·95861	44	1·64345	8·35655	77	1·88649	8·11351
12	1·07918	8·92082	45	1·65321	8·34679	78	1·89209	8·10791
13	1·11394	8·88605	46	1·66276	8·33724	79	1·89763	8·10237
14	1·14613	8·85387	47	1·67210	8·32790	80	1·90309	8·09691
15	1·17609	8·82391	48	1·68124	8·31876	81	1·90848	8·09152
16	1·20412	8·79588	49	1·69020	8·30980	82	1·91381	8·08619
17	1·23045	8·76955	50	1·69897	8·30103	83	1·91908	8·08092
18	1·25527	8·74473	51	1·70757	8·29243	84	1·92428	8·07572
19	1·27875	8·72125	52	1·71600	8·28400	85	1·92942	8·07058
20	1·30103	8·69897	53	1·72428	8·27572	86	1·93450	8·06550
21	1·32222	8·67778	54	1·73239	8·26761	87	1·93952	8·06048
22	1·34242	8·65758	55	1·74036	8·25964	88	1·94448	8·05552
23	1·36173	8·63827	56	1·74819	8·25181	89	1·94939	8·05061
24	1·38021	8·61979	57	1·75587	8·24413	90	1·95424	8·04576
25	1·39794	8·60206	58	1·76343	8·23657	91	1·95904	8·04096
26	1·41497	8·58503	59	1·77085	8·22915	92	1·96379	8·03621
27	1·43136	8·56864	60	1·77815	8·22185	93	1·96848	8·03152
28	1·44716	8·55284	61	1·78533	8·21467	94	1·97313	8·02687
29	1·46240	8·53760	62	1·79239	8·20761	95	1·97772	8·02228
30	1·47712	8·52288	63	1·79934	8·20066	96	1·98227	8·01773
31	1·49136	8·50864	64	1·80618	8·19382	97	1·98677	8·01323
32	1·50515	8·49485	65	1·81291	8·18709	98	1·99123	8·00877
33	1·51854	8·48149	66	1·81954	8·18046	99	1·99563	8·00437

N	Logarithms. 0	1	2	3	4	5	6	7	8	9	Complements. 0	1	2	3	4	5	6	7	8	9
100	[illegible]	043	087	130	173	[illegible]	260	302	346	389	00000	957	913	870	827	783	740	697	654	611
101	432	475	518	561	604	647	689	732	775	817	99568	[illegible]	482	438	396	353	311	268	225	183
102	860	[illegible]	945	988	.30	.72	115	157	199	241	140	097	055	012	970	928	885	843	801	759
103	01284	326	368	410	452	494	536	578	620	662	98716	674	632	590	548	506	464	422	380	338
104	703	745	787	828	870	912	953	995	[illegible]	.77	297	255	213	172	130	088	047	005	964	[illegible]
105	02119	160	202	243	284	325	[illegible]	407	449	490	97881	840	798	757	716	675	634	593	551	[illegible]
106	531	571	612	653	694	735	[illegible]	816	857	898	469	[illegible]	[illegible]	347	306	265	224	184	143	102
107	938	979	.19	.60	100	141	181	222	262	[illegible]	062	021	981	940	900	859	819	778	738	698
108	03342	383	423	463	503	543	583	623	[illegible]	[illegible]	96658	617	577	537	497	457	417	377	337	297
109	743	782	822	862	902	941	981	.21	[illegible]	[illegible]	[illegible]	218	178	138	098	059	019	979	940	900
110	04139	179	218	258	297	336	376	415	454	493	95861	821	782	742	703	664	625	585	546	507
111	532	571	610	649	688	727	766	805	844	883	468	429	390	351	312	273	234	195	156	117
112	922	961	999	.38	.77	115	154	192	231	269	078	039	001	962	923	885	846	808	769	731
113	05308	346	385	423	461	500	538	576	614	652	94692	654	615	577	539	500	462	424	386	348
114	690	729	767	805	843	880	918	956	994	.32	310	271	233	195	157	120	082	044	006	[illegible]
115	06070	107	145	183	221	258	296	333	371	408	93930	893	855	817	779	742	704	667	629	592
116	446	483	521	558	595	633	670	707	744	781	554	517	479	442	405	367	330	293	256	219
117	819	856	[illegible]	930	967	..4	.41	.78	114	151	181	144	107	070	033	996	959	922	886	849
118	07188	225	[illegible]	298	335	372	408	[illegible]	482	518	92812	775	738	702	665	628	592	555	518	482
119	555	591	628	664	700	737	773	809	846	882	445	409	372	336	300	263	227	191	154	118
120	918	954	990	.27	.63	.99	135	171	207	243	082	046	010	973	937	901	865	839	793	757
121	08278	314	350	386	422	458	493	529	565	600	91722	686	650	614	578	542	507	471	435	400
122	636	672	707	743	778	814	849	884	920	955	364	328	293	257	222	186	151	116	080	045
123	990	.26	.61	.96	131	167	202	237	272	307	010	974	939	904	869	833	798	763	728	693
124	09342	377	412	447	482	517	552	587	621	656	90658	623	588	553	518	483	448	413	379	344
125	691	726	760	795	830	864	899	933	968	..3	309	[illegible]	[illegible]	205	170	136	101	067	032	997
126	10037	071	[illegible]	140	175	209	243	278	312	346	89963	929	[illegible]	860	825	791	757	721	688	654
127	380	415	449	483	517	551	585	619	653	687	620	585	[illegible]	517	483	449	415	382	347	313
128	721	755	789	823	856	890	924	958	992	.25	279	245	211	177	144	110	076	042	008	975
129	11059	093	126	160	193	227	260	294	327	361	88941	907	874	840	807	773	740	706	673	639
130	394	428	461	494	528	561	594	628	661	694	606	572	539	506	472	439	406	372	339	306
131	727	760	793	826	859	893	926	959	991	.24	273	240	207	174	141	107	074	041	009	976
132	12057	090	123	156	189	222	254	287	320	352	87943	910	877	844	811	778	746	713	680	648
133	385	418	450	483	516	548	581	613	646	678	615	582	550	517	484	452	419	387	354	322
134	710	743	775	808	840	872	904	937	969	..1	290	257	225	192	160	128	096	063	031	999
135	13033	065	098	130	162	194	226	258	290	322	86967	935	902	870	838	806	774	742	710	678
136	354	386	418	450	481	513	545	577	609	640	646	614	582	550	519	487	455	423	391	[illegible]
137	672	704	735	767	799	830	862	893	925	956	328	296	265	233	201	170	138	107	075	044
138	988	.19	.51	.82	114	145	176	208	239	270	012	981	949	918	886	855	824	792	761	730
139	14301	333	364	395	426	457	488	520	551	582	85699	667	636	605	574	543	512	480	449	418
140	613	644	675	706	737	768	798	829	860	891	387	356	325	294	263	232	202	171	140	109
141	922	953	983	.14	.45	.76	106	137	168	198	078	047	017	986	955	924	894	863	832	802
142	15229	259	290	320	351	381	412	442	473	503	84771	741	710	680	649	619	588	558	527	497
143	534	564	594	625	655	685	715	746	776	806	466	436	406	375	345	315	285	254	224	194
144	836	866	896	927	957	987	.17	.47	.77	107	164	134	104	073	043	013	983	953	923	893
145	16137	167	197	227	256	286	316	346	376	405	83863	833	803	773	744	714	684	654	624	595
146	435	465	495	524	554	584	613	643	673	702	565	535	505	476	446	416	387	357	327	298
147	732	761	791	820	850	879	909	938	967	997	268	239	209	180	150	121	091	062	033	003
148	17026	056	085	114	143	173	202	231	260	289	82974	945	915	886	857	827	798	779	740	711
149	319	348	377	406	435	464	493	522	551	580	681	652	623	594	565	536	507	478	449	420

N	Logarithms. 0	1	2	3	4	5	6	7	8	9	Complements. 0	1	2	3	4	5	6	7	8	9
150	17609	638	667	696	725	754	782	811	840	869	82391	362	333	304	275	246	218	189	160	131
151	898	926	955	984	.13	.41	.70	.99	127	156	102	074	045	016	987	959	930	901	873	844
152	18184	213	241	270	298	327	355	384	412	441	81816	787	759	730	702	673	645	616	588	559
153	469	497	526	554	582	611	639	667	696	724	531	503	474	446	418	389	361	333	304	276
154	752	780	808	837	865	893	921	949	977	..5	248	220	192	163	135	107	079	051	023	995
155	19033	061	089	117	145	173	201	229	257	285	80967	939	911	883	855	827	799	771	743	715
156	312	340	368	396	424	451	479	507	535	562	688	660	632	604	576	549	521	493	465	438
157	590	618	645	673	700	728	756	783	811	838	410	382	355	327	300	272	244	217	189	162
158	866	893	921	948	975	..3	.30	.58	.85	112	134	107	079	052	025	997	970	942	915	888
159	20140	167	194	222	249	276	303	330	358	385	79860	833	806	778	751	724	697	670	642	615
160	412	439	466	493	520	547	575	602	629	656	588	561	534	507	480	453	425	398	371	344
161	683	710	736	763	790	817	844	871	898	925	317	290	264	237	210	183	156	129	102	075
162	951	978	..5	.32	.59	.85	112	139	165	192	049	022	995	968	941	915	888	861	835	808
163	21219	245	272	299	325	352	378	405	431	458	78781	755	728	701	675	648	622	595	569	542
164	484	511	537	564	590	617	643	669	696	722	516	489	463	436	410	383	357	331	304	278
165	748	775	801	827	854	880	906	932	958	985	252	225	199	173	146	120	094	068	042	015
166	22011	037	063	089	115	141	167	194	220	246	77989	963	937	911	885	859	833	806	780	754
167	272	298	324	350	375	401	427	453	479	505	728	702	676	650	625	599	573	547	521	495
168	531	557	583	608	634	660	686	711	737	763	469	443	417	392	366	340	314	289	263	237
169	789	814	840	866	891	917	943	968	994	.19	211	186	160	134	109	083	057	032	006	981
170	23045	070	096	121	147	172	198	223	249	274	76955	930	904	879	853	828	802	777	751	726
171	300	325	350	376	401	426	452	477	502	528	700	675	650	624	599	574	548	523	498	472
172	553	578	603	628	654	679	704	729	754	779	447	422	397	372	346	321	296	271	246	221
173	805	830	855	880	905	930	955	980	..5	.30	195	170	145	120	095	070	045	020	995	970
174	24055	080	105	130	155	179	204	229	254	279	75945	920	895	870	845	821	796	771	746	721
175	304	329	353	378	403	428	452	477	502	527	696	671	647	622	597	572	548	523	498	473
176	551	576	601	625	650	674	699	724	748	773	449	424	399	375	350	326	301	276	252	227
177	797	822	846	871	895	920	944	969	993	.18	203	178	154	129	105	080	056	031	007	982
178	25042	066	091	115	139	164	188	212	237	261	74958	934	909	855	861	836	812	788	763	739
179	285	310	334	358	382	406	431	455	479	503	715	690	666	642	618	594	569	545	521	497
180	527	551	575	600	624	648	672	696	720	744	473	449	425	400	376	352	328	304	280	256
181	768	792	816	840	864	888	912	935	959	983	232	208	184	160	136	112	088	065	041	017
182	26007	031	055	079	102	126	150	174	198	221	73993	969	945	921	898	874	850	826	802	779
183	245	269	292	316	340	364	387	411	435	458	755	731	708	684	660	636	613	589	565	542
184	482	505	529	552	576	600	623	647	670	694	518	495	471	448	424	400	377	353	330	306
185	717	741	764	787	811	834	858	881	905	928	283	259	236	213	189	166	142	119	095	072
186	951	975	998	.21	.45	.68	.91	114	138	161	049	025	002	979	955	932	909	886	862	839
187	27184	207	231	254	277	300	323	346	370	393	72816	793	769	746	723	700	677	654	630	607
188	416	440	462	485	503	531	554	577	600	623	584	560	538	515	497	469	446	423	400	377
189	646	669	692	715	738	761	784	807	830	852	354	331	308	285	262	239	216	193	170	148
190	875	898	921	944	967	989	.12	.35	.58	.81	125	102	079	056	033	011	988	965	942	919
191	28103	126	149	171	194	217	240	262	285	307	71897	874	851	829	806	783	760	738	715	693
192	330	353	375	398	420	443	466	488	511	533	670	647	625	602	580	557	534	512	489	467
193	556	578	601	623	646	668	690	713	735	758	444	422	399	377	354	332	310	287	265	242
194	780	803	825	847	870	892	914	937	959	981	220	197	175	153	130	108	086	063	041	019
195	29003	026	048	070	092	115	137	159	181	203	70997	974	952	930	908	885	863	841	819	797
196	226	248	270	292	314	336	358	380	402	425	774	752	730	708	686	664	642	620	598	575
197	447	469	491	513	535	557	579	601	623	645	553	531	509	487	465	443	421	399	377	355
198	666	688	710	732	754	776	798	820	842	863	334	312	290	268	246	224	202	180	158	137
199	885	907	929	951	972	994	.16	.38	.59	.81	115	093	071	049	028	006	984	962	941	919

N	Logarithms. 0	1	2	3	4	5	6	7	8	9	Complements. 0	1	2	3	4	5	6	7	8	9
200	30103	125	146	168	190	211	233	255	276	298	69897	875	854	832	810	789	767	745	724	702
201	320	341	363	384	406	427	449	471	492	514	680	659	637	616	594	573	551	529	508	486
202	535	557	578	600	621	642	664	685	707	728	465	443	422	400	379	358	336	315	293	272
203	750	771	792	814	835	856	878	899	920	942	250	229	208	186	165	144	122	101	080	068
204	963	984	..6	.27	.48	.69	.91	112	133	154	037	016	994	973	952	931	909	888	867	846
205	31175	197	218	239	260	281	302	323	344	366	68825	803	782	761	740	719	698	677	656	634
206	387	408	429	450	471	492	513	534	555	576	613	592	571	550	529	508	487	466	445	424
207	597	618	639	660	681	702	723	744	765	785	403	382	361	340	319	298	277	256	235	215
208	806	827	848	869	890	911	931	952	973	994	194	173	152	131	110	089	069	048	027	006
209	32015	035	056	077	098	118	139	160	180	201	67985	965	944	923	902	882	861	840	820	799
210	222	243	263	284	305	325	346	366	387	408	778	757	737	716	695	675	654	634	613	592
211	428	449	469	490	510	531	552	572	593	613	572	551	531	510	490	469	448	428	407	387
212	634	654	674	695	715	736	756	777	797	818	366	346	326	305	285	264	244	223	203	182
213	838	858	879	899	919	940	960	980	..1	.21	162	142	121	101	081	060	040	020	999	979
214	33041	062	082	102	122	143	163	183	203	224	66959	938	918	898	878	857	837	827	797	776
215	244	264	284	304	325	345	365	385	405	425	756	736	716	696	675	655	635	615	595	575
216	445	465	486	506	526	546	566	586	606	626	555	535	514	494	474	454	434	414	394	374
217	646	666	686	706	726	746	766	786	806	826	354	334	314	294	274	254	234	214	194	174
218	846	866	885	905	925	945	965	985	..5	.25	154	134	115	095	075	055	035	015	995	975
219	34044	064	084	104	124	143	163	183	203	222	65956	936	916	896	876	857	837	817	797	778
220	242	262	282	301	321	341	361	380	400	420	758	738	718	699	679	659	639	620	600	580
221	439	459	478	498	518	537	557	577	596	616	561	541	522	502	482	463	443	423	404	384
222	635	655	674	694	713	733	752	772	791	811	365	345	326	306	287	267	248	228	209	189
223	830	850	869	889	908	928	947	967	986	..5	170	150	131	111	092	072	053	033	014	995
224	35025	044	064	083	102	122	141	160	180	199	64975	956	936	917	898	878	859	840	820	801
225	218	237	257	276	295	315	334	353	372	392	782	763	743	724	705	685	666	647	628	608
226	411	430	449	468	488	507	526	545	564	583	589	570	551	532	512	493	474	455	436	417
227	603	622	641	660	679	698	717	736	755	774	397	378	359	340	321	302	283	264	245	226
228	793	812	832	851	870	889	908	927	946	965	207	188	168	149	130	111	092	073	054	035
229	983	..2	.21	.40	.59	.78	.97	116	135	154	017	998	979	960	941	922	903	884	865	846
230	36173	192	210	229	248	267	286	305	324	342	63827	308	790	771	752	733	714	695	676	658
231	361	380	399	418	436	455	474	493	511	530	639	620	601	582	564	545	526	507	489	470
232	549	567	586	605	624	642	661	680	698	717	451	433	414	395	376	358	339	320	302	283
233	736	754	773	791	810	829	847	866	884	903	264	246	227	209	190	171	153	134	116	097
234	922	940	959	977	996	.14	.33	.51	.70	.88	078	060	041	023	004	986	967	949	930	912
235	37107	125	144	162	181	199	217	236	254	273	62893	875	856	838	829	801	783	764	746	727
236	291	310	328	346	365	383	401	420	438	456	709	690	672	654	635	617	599	580	562	544
237	475	493	511	530	548	566	585	603	621	639	525	507	489	470	452	434	415	397	379	361
238	658	676	694	712	731	749	767	785	803	822	342	324	306	288	269	251	233	215	197	178
239	840	858	876	894	912	931	949	967	985	..3	160	142	124	106	088	069	051	033	015	997
240	38021	039	057	075	093	111	130	148	166	184	61979	961	943	925	907	889	870	852	834	826
241	202	220	238	256	274	292	310	328	346	364	798	780	762	744	726	708	690	672	654	636
242	381	399	417	435	453	471	489	507	525	543	619	601	583	565	547	529	511	493	475	457
243	561	578	596	614	632	650	668	686	703	721	439	422	404	386	368	350	332	314	297	279
244	739	757	775	792	810	828	846	863	881	899	261	243	225	208	190	172	154	137	119	101
245	917	934	952	970	987	..5	.23	.40	.58	.76	083	066	048	030	013	995	977	960	942	924
246	39093	111	129	146	164	182	199	217	234	252	60907	889	871	854	836	818	801	783	766	748
247	270	287	305	322	340	357	375	393	410	426	730	713	695	678	660	643	625	607	590	572
248	445	463	480	498	515	533	550	568	585	602	555	537	520	502	485	467	450	432	415	398
249	620	637	655	672	690	707	724	742	759	776	380	363	345	328	310	293	276	258	241	224

	Logarithms.										Complements.									
N	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
250	39794	811	829	846	863	881	898	915	933	950	60206	189	171	154	137	119	102	085	[illegible]	050
251	967	985	..2	.19	.36	.54	.71	.88	106	123	033	015	998	981	964	946	929	912	894	877
252	40140	[illegible]	174	192	209	226	243	260	278	295	59860	843	826	808	791	774	757	[illegible]	722	705
253	312	329	346	363	[illegible]	398	415	432	449	466	688	671	654	637	619	602	585	[illegible]	551	534
254	483	500	518	535	552	569	586	603	620	637	517	500	482	465	448	431	414	397	380	363
255	654	671	688	705	722	739	756	773	790	807	346	329	312	295	278	261	244	227	210	193
256	824	841	858	875	892	909	926	943	959	976	176	159	142	125	108	091	074	057	041	024
257	993	.10	.27	.44	.61	.78	.95	111	[illegible]	145	007	990	973	956	939	922	905	889	872	855
258	41162	179	196	212	229	246	263	280	[illegible]	313	58838	821	804	788	771	754	737	720	704	687
259	330	347	363	380	397	414	430	447	464	481	670	653	637	620	603	586	570	553	536	519
260	497	514	531	547	564	581	597	614	631	647	503	486	469	453	436	419	403	386	369	353
261	664	681	697	714	731	747	764	780	797	813	336	319	303	286	269	253	236	220	203	187
262	830	846	863	880	896	913	929	946	962	979	170	153	137	120	104	087	071	054	038	021
263	996	.12	.29	.45	.62	.78	.94	111	127	144	004	988	971	955	938	922	906	889	873	856
264	42160	177	193	210	226	243	259	275	292	308	57840	823	807	790	774	757	741	735	708	692
265	325	341	357	374	390	406	423	439	455	472	675	659	643	626	610	594	577	561	545	528
266	488	504	521	537	553	570	586	602	619	635	512	496	479	463	447	430	414	398	381	365
267	651	667	684	700	716	732	749	765	781	797	349	333	316	300	284	268	251	235	219	203
268	813	830	846	862	878	894	911	927	943	959	187	170	154	138	122	106	089	073	057	041
269	975	991	..7	.24	.40	.56	.72	.88	104	120	025	009	993	976	960	944	928	912	896	880
270	43136	152	168	185	201	217	233	249	265	281	56864	858	832	815	799	783	767	751	735	719
271	297	313	329	345	361	377	393	409	425	441	703	687	671	655	639	623	607	591	575	559
272	457	473	489	505	521	537	553	568	584	600	543	527	511	495	479	465	447	432	416	400
273	616	632	648	664	680	696	712	727	743	759	384	368	352	336	320	304	288	273	257	241
274	775	791	807	823	838	854	870	886	902	917	225	209	193	177	162	146	130	114	098	083
275	933	949	965	981	996	.12	.28	.44	.59	.75	067	051	035	019	004	988	972	956	941	925
276	44091	107	122	138	154	169	185	201	217	232	55909	893	878	862	846	831	815	799	783	768
277	248	264	279	295	311	326	342	358	373	389	752	736	721	705	689	674	658	642	627	611
278	404	420	436	451	467	482	498	514	529	545	596	580	564	549	533	518	502	486	471	455
279	560	576	591	607	623	638	654	669	685	700	440	424	409	393	377	362	346	331	315	300
280	716	731	747	762	778	793	809	824	840	855	284	269	253	238	222	207	191	176	160	145
281	871	886	901	917	932	948	963	979	994	..9	54129	114	099	083	068	052	037	021	006	991
282	45025	040	056	071	086	102	117	133	148	163	975	960	944	929	914	898	883	867	852	837
283	179	194	209	225	240	255	271	286	301	316	821	806	791	775	760	745	729	714	699	684
284	332	347	362	378	393	408	423	439	454	469	668	653	638	622	607	592	577	561	546	531
285	484	500	515	530	545	561	576	591	606	621	516	500	485	470	455	439	424	409	394	379
286	637	652	667	682	697	712	728	743	758	773	363	348	333	318	303	288	272	257	242	227
287	768	803	818	834	849	864	879	894	909	924	212	197	182	166	151	136	121	106	091	076
288	939	954	969	984	999	.15	.30	.45	.60	.75	061	046	031	016	001	985	970	955	940	925
289	46090	105	120	135	150	165	180	195	210	225	53910	895	880	865	850	835	820	805	790	775
290	240	255	270	285	300	315	330	344	359	374	760	745	730	715	700	685	670	656	641	626
291	389	404	419	434	449	464	479	494	508	523	611	596	581	566	551	536	521	506	492	477
292	538	553	568	583	598	613	627	642	657	672	462	447	432	427	402	387	373	358	343	328
293	687	702	716	731	746	761	776	790	805	820	313	298	284	269	254	239	224	210	195	180
294	835	849	864	879	894	908	923	938	953	967	165	151	136	121	106	092	077	062	047	033
295	982	997	.12	.26	.41	.56	.70	.85	100	114	018	003	988	974	969	944	930	915	900	886
296	47129	144	158	173	188	202	217	232	246	261	52871	856	842	827	812	798	783	768	754	739
297	276	290	305	319	334	349	363	378	392	407	724	710	695	681	666	651	637	622	608	593
298	422	436	451	465	480	494	509	523	538	553	578	564	549	535	520	506	491	477	462	447
299	567	582	596	611	625	640	654	669	683	698	433	418	404	389	375	360	346	331	317	302

N	Logarithms. 0	1	2	3	4	5	6	7	8	9	Complements. 0	1	2	3	4	5	6	7	8	9
300	[illegible]712	727	741	755	770	784	799	[illegible]	828	842	52288	273	259	245	230	216	201	187	172	158
301	857	871	885	900	914	929	943	957	972	986	143	129	115	100	086	071	057	043	028	014
302	48001	015	029	044	058	072	087	101	116	130	51999	985	971	956	942	928	[illegible]	899	884	870
303	144	[illegible]	173	187	202	216	230	244	259	273	856	841	827	[illegible]	798	784	770	756	741	727
304	287	302	316	330	344	359	373	387	401	416	713	698	684	670	656	641	627	613	599	584
305	430	444	458	473	487	501	515	529	544	558	570	556	542	527	513	499	485	471	456	442
306	572	586	600	615	629	643	657	671	685	700	428	414	400	385	371	357	34	329	315	300
307	714	728	742	756	770	784	799	813	827	841	286	272	258	244	230	216	201	187	173	159
308	855	869	883	897	911	925	940	954	968	982	145	131	117	103	089	075	060	046	032	018
309	996	.10	.24	.38	.52	.66	.80	.94	108	[illegible]	004	990	976	962	948	934	920	906	892	878
310	49136	150	164	178	192	206	220	234	248	262	50864	850	836	822	808	794	780	766	752	738
311	276	290	304	318	332	346	360	374	388	401	724	710	696	682	668	654	640	626	612	599
312	415	429	443	457	471	485	499	513	527	541	585	571	557	543	529	515	[illegible]	487	473	459
313	554	568	582	596	610	624	638	651	665	679	446	432	418	404	390	376	[illegible]	349	335	321
314	693	707	721	734	748	762	776	790	803	817	307	293	279	266	252	238	224	210	197	183
315	831	845	859	872	886	900	914	927	941	955	169	155	141	128	114	100	086	073	059	045
316	969	982	996	.10	.24	.37	.51	.65	.78	.92	031	018	004	990	976	963	949	935	922	908
317	50106	120	133	147	161	174	188	202	215	229	49894	880	867	853	839	826	812	798	785	771
318	243	256	270	284	297	311	325	338	352	365	757	744	730	716	703	689	675	662	648	635
319	379	393	406	420	433	447	461	474	488	501	621	607	594	580	567	553	539	526	512	499
320	515	529	542	556	569	583	596	610	623	637	485	471	458	444	431	417	404	390	377	363
321	650	664	678	691	705	718	732	745	759	772	350	336	322	309	295	282	268	255	241	228
322	786	799	813	826	839	853	866	880	893	907	214	201	187	174	161	147	134	120	107	093
323	920	934	947	961	974	987	..1	.14	.28	.41	080	066	053	039	026	013	999	986	972	959
324	51054	068	081	095	108	121	135	148	162	175	48946	932	919	905	892	879	865	852	838	825
325	188	202	215	228	242	255	268	282	295	308	812	798	785	772	758	745	732	718	705	692
326	322	335	348	362	375	388	402	415	428	441	678	665	652	[illegible]	625	612	598	585	572	559
327	455	468	481	495	508	521	534	548	561	574	545	532	519	505	492	479	466	452	439	426
328	587	601	614	627	640	653	667	680	693	706	413	399	386	373	360	347	333	320	307	294
329	720	733	746	759	772	785	799	812	825	838	280	267	254	241	228	215	[illegible]	188	175	162
330	851	865	878	891	904	917	930	943	957	970	149	135	122	109	096	083	070	057	043	030
331	983	996	..9	.22	.35	.48	.61	.74	.88	101	017	004	991	978	965	952	939	926	912	899
332	52114	127	140	153	166	179	192	205	218	231	47886	873	860	847	834	821	808	795	782	769
333	244	257	270	283	297	310	323	336	349	362	756	743	730	717	703	690	[illegible]	664	651	638
334	375	388	401	414	427	440	453	466	479	491	625	612	599	586	573	560	547	534	522	509
335	504	517	530	543	556	569	582	595	608	621	496	483	470	457	444	431	418	405	392	379
336	634	647	660	673	686	698	711	724	737	750	366	353	340	327	314	302	289	276	263	250
337	763	776	789	802	814	827	840	853	866	879	237	224	211	198	186	173	160	147	134	121
338	892	904	917	930	943	956	969	981	994	..7	108	096	083	070	057	044	031	019	006	993
339	53020	033	046	058	071	084	097	110	122	135	46980	967	954	942	929	916	903	890	878	865
340	148	161	173	186	199	212	224	237	250	263	852	839	827	814	801	788	776	763	750	737
341	275	288	301	314	326	339	352	364	377	390	725	712	699	686	674	661	648	636	62[illegible]	610
342	403	415	428	441	453	466	479	491	504	517	597	585	572	559	547	534	521	509	496	483
343	529	542	555	567	[illegible]	593	605	618	631	643	471	458	445	433	420	407	395	382	369	357
344	656	668	681	694	706	719	731	744	757	769	344	332	319	306	294	281	269	256	242	231
345	782	794	807	820	832	845	857	870	882	895	218	206	193	180	168	155	143	130	118	105
346	908	920	933	945	958	970	983	995	..8	.20	092	080	067	055	042	030	017	005	992	980
347	54033	045	058	070	083	095	108	120	133	145	45967	955	942	930	917	905	892	880	867	855
348	158	170	183	195	208	220	233	245	258	270	842	830	817	805	792	780	767	755	742	730
349	282	295	307	320	332	345	357	370	382	394	718	705	693	680	668	655	643	630	618	606

N	Logarithms. 0	1	2	3	4	5	6	7	8	9	Complements. 0	1	2	3	4	5	6	7	8	9
350	54407	419	432	444	456	469	481	494	506	518	45593	581	568	556	544	531	519	506	494	482
351	531	543	555	568	580	592	605	617	630	642	469	457	445	432	420	408	395	383	370	358
352	654	667	679	691	704	716	728	740	753	765	346	333	321	309	296	284	272	260	247	235
353	777	790	802	814	827	839	851	863	876	888	223	210	198	186	173	161	149	137	124	112
354	900	913	925	937	949	962	974	986	998	.11	100	087	075	063	051	038	026	014	002	989
355	55023	035	047	059	072	084	096	108	121	133	44977	965	953	941	928	916	904	892	879	867
356	145	157	169	182	194	206	218	230	242	255	855	843	831	818	806	794	782	770	758	745
357	267	279	291	303	315	328	340	352	364	376	733	721	709	697	685	672	660	648	636	624
358	388	400	413	425	437	449	461	473	485	497	612	600	587	575	563	551	539	527	515	503
359	509	521	534	546	558	570	582	594	606	618	491	479	466	454	442	430	418	406	394	382
360	630	642	654	666	678	690	703	715	727	739	370	358	346	334	322	310	297	285	273	261
361	751	763	775	787	799	811	823	835	847	859	249	237	225	213	201	189	177	165	153	141
362	871	883	895	907	919	931	943	955	967	979	129	117	105	093	081	069	057	045	033	021
363	991	..3	.15	.26	.38	.50	.62	.74	.86	.98	009	997	985	974	962	950	938	926	914	902
364	56110	122	134	146	158	170	182	194	205	217	43890	878	866	854	842	830	818	806	795	783
365	229	241	253	265	277	289	301	312	324	336	771	759	747	735	723	711	699	688	676	664
366	348	360	372	384	395	407	419	431	443	455	652	640	628	616	605	593	581	569	557	545
367	467	478	490	502	514	526	538	549	561	573	533	522	510	498	486	474	462	451	439	427
368	585	597	608	620	632	644	655	667	679	691	415	403	392	380	368	356	345	333	321	309
369	703	714	726	738	750	761	773	785	797	808	297	286	274	262	250	239	227	215	203	192
370	820	832	844	855	867	879	890	902	914	926	180	168	156	145	133	121	110	098	086	074
371	937	949	961	972	984	996	..8	.19	.31	.43	063	051	039	028	016	004	992	981	969	957
372	57054	066	078	089	101	113	124	136	148	159	42946	934	922	911	899	887	876	864	852	841
373	171	182	194	206	217	229	241	252	264	275	829	818	806	794	783	771	759	748	736	725
374	287	299	310	322	334	345	357	368	380	391	713	701	690	678	666	655	643	632	620	609
375	403	415	426	438	449	461	473	484	496	507	597	585	574	562	551	539	527	516	504	493
376	519	530	542	553	565	576	588	600	611	623	481	470	458	447	435	424	412	400	389	377
377	634	646	657	669	680	692	703	715	726	738	366	354	343	331	320	308	297	285	274	262
378	749	761	772	784	795	807	818	829	841	852	251	239	228	216	205	193	182	171	159	148
379	864	875	887	898	910	921	933	944	955	967	136	125	113	102	090	079	067	056	045	033
380	978	990	..1	.13	.24	.35	.47	.58	.70	.81	022	010	999	987	976	965	953	942	930	919
381	58092	104	115	127	138	149	161	172	184	195	41908	896	885	873	862	851	839	828	816	805
382	206	218	229	240	252	263	274	286	297	308	794	782	771	760	748	737	726	714	703	692
383	320	331	343	354	365	376	388	399	410	422	680	669	657	646	635	624	612	601	590	578
384	433	444	456	467	478	490	501	512	523	535	567	556	544	533	522	510	499	488	477	465
385	546	557	569	580	591	602	614	625	636	647	454	443	431	420	409	398	386	375	364	353
386	659	670	681	692	704	715	726	737	749	760	341	330	319	308	296	285	274	263	251	240
387	771	782	793	805	816	827	838	850	861	872	229	218	207	195	184	173	162	150	139	128
388	883	894	906	917	928	939	950	961	973	984	117	106	094	083	072	061	050	039	027	016
389	995	..6	.17	.28	.40	.51	.62	.73	.84	.95	005	994	983	972	960	949	938	927	916	905
390	59106	118	129	140	151	162	173	184	195	207	40894	882	871	860	849	838	827	816	805	793
391	218	229	240	251	262	273	284	295	306	317	782	771	760	749	738	727	716	705	694	683
392	329	340	351	362	373	384	395	406	417	428	671	660	649	638	627	616	605	594	583	572
393	439	450	461	472	483	494	505	516	528	539	561	550	539	528	517	506	495	484	472	461
394	550	561	572	583	594	605	616	627	638	649	450	439	428	417	406	395	384	373	362	351
395	660	671	682	693	704	715	726	737	748	759	340	329	318	307	296	285	274	263	252	241
396	769	780	791	802	813	824	835	846	857	868	231	220	209	198	187	176	165	154	143	132
397	879	890	901	912	923	934	945	956	966	977	121	110	099	088	077	066	055	044	033	023
398	988	999	.10	.21	.32	.43	.54	.65	.75	.86	012	001	990	979	968	957	946	935	925	914
399	60097	108	119	130	141	152	162	173	184	195	39903	892	881	870	859	848	838	827	816	805

	Logarithms.										Complements.									
N	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
400	60206	217	228	239	249	260	271	282	293	304	39794	783	772	761	751	740	729	718	707	696
401	314	325	336	347	357	369	379	390	401	412	686	675	664	653	643	631	621	610	599	588
402	423	433	444	455	466	477	487	498	509	520	577	567	556	545	534	523	513	502	491	480
403	530	541	552	563	574	584	595	606	617	627	470	459	448	437	426	416	405	394	383	373
404	638	649	660	670	681	692	703	713	724	735	362	351	340	330	319	308	297	287	276	265
405	745	756	767	778	788	799	810	820	831	842	255	244	233	222	212	201	190	180	169	158
406	853	863	874	885	895	906	917	927	938	949	147	137	126	115	105	094	083	073	062	051
407	959	970	981	991	..2	.13	.23	.34	.45	.55	041	030	019	009	998	987	977	966	955	945
408	61066	077	087	098	109	119	130	140	151	162	38934	923	913	902	891	881	870	860	849	838
409	172	183	194	204	215	225	236	247	257	269	828	817	806	796	785	775	764	753	743	731
410	278	289	300	310	321	331	342	352	363	374	722	711	700	690	679	669	658	648	637	626
411	384	395	405	416	426	437	447	458	469	479	616	605	595	584	574	563	553	542	531	521
412	490	500	511	521	532	542	553	563	574	584	510	500	489	479	468	458	447	437	426	416
413	595	605	616	626	637	648	658	669	679	689	405	395	384	374	363	352	342	331	321	311
414	700	710	721	731	742	752	763	773	784	794	300	290	279	269	258	248	237	227	216	206
415	805	815	826	836	847	857	868	878	888	899	195	185	174	164	153	143	132	122	112	101
416	909	920	930	941	951	961	972	982	993	..3	091	080	070	059	049	039	028	018	007	997
417	62014	024	034	045	055	066	076	086	097	107	37986	976	966	955	945	934	924	914	903	893
418	118	128	138	149	159	169	180	190	201	211	882	872	862	851	841	831	820	810	799	789
419	221	232	242	252	263	273	283	294	304	315	779	768	758	748	737	727	717	706	696	685
420	325	335	346	356	366	377	387	397	408	418	675	665	654	644	634	623	613	603	592	582
421	428	438	449	459	469	480	490	500	511	521	572	562	551	541	531	520	510	500	489	479
422	531	541	552	562	572	583	593	603	613	624	469	459	448	438	428	417	407	397	387	376
423	634	644	655	665	675	685	696	706	716	726	366	356	345	335	325	315	304	294	284	274
424	737	747	757	767	777	788	798	808	818	829	263	253	243	233	223	212	202	192	182	171
425	839	849	859	869	880	890	900	910	921	931	161	151	141	131	120	110	100	090	079	069
426	941	951	961	971	982	992	..2	.12	.22	.33	059	049	039	029	018	008	998	988	978	967
427	63043	053	063	073	083	094	104	114	124	134	36957	947	937	927	917	906	896	886	876	866
428	144	154	165	175	185	195	205	215	225	236	856	846	835	825	815	805	795	785	775	764
429	246	256	266	276	286	296	306	316	327	337	754	744	734	724	714	704	694	684	673	663
430	347	357	367	377	387	397	407	417	428	438	653	643	633	623	613	603	593	583	572	562
431	448	458	468	478	488	498	508	518	528	538	552	542	532	522	512	502	492	482	472	462
432	548	558	568	578	589	599	609	619	629	639	452	442	432	422	411	401	391	381	371	361
433	649	659	669	679	689	699	709	719	729	739	351	341	331	321	311	301	291	281	271	261
434	749	759	769	779	789	799	809	819	829	839	251	241	231	221	211	201	191	181	171	161
435	849	859	869	879	889	899	909	919	929	939	151	141	131	121	111	101	091	081	071	061
436	949	959	969	978	988	998	..8	.18	.28	.38	051	041	031	022	012	002	992	982	972	962
437	64048	058	068	078	088	098	108	118	128	137	35952	942	932	922	912	902	892	882	872	863
438	147	157	167	177	187	197	207	217	227	237	853	843	833	823	813	803	793	783	773	763
439	246	256	266	276	286	296	306	316	325	335	754	744	734	724	714	704	694	684	675	665
440	345	355	365	375	385	395	404	414	424	434	655	645	635	625	615	605	596	586	576	566
441	444	454	464	473	483	493	503	513	523	532	556	546	536	527	517	507	497	487	477	468
442	542	552	562	572	581	591	601	611	621	631	458	448	438	428	419	409	399	389	379	369
443	640	650	660	670	680	689	699	709	719	728	360	350	340	330	320	311	301	291	281	272
444	738	748	758	768	777	787	797	807	816	826	262	252	242	232	223	213	203	193	184	174
445	836	846	856	865	875	885	894	904	914	924	164	154	144	135	125	115	106	096	086	076
446	933	943	953	963	972	982	992	..2	.11	.21	067	057	047	037	028	018	008	998	989	979
447	65031	040	050	060	070	079	089	099	108	118	34969	960	950	940	930	921	911	901	892	882
448	128	137	147	157	167	176	186	196	205	215	872	863	853	843	833	824	814	804	795	785
449	225	234	244	254	263	273	283	292	302	312	775	766	756	746	737	727	717	708	698	688

	Logarithms.										Complements.									
N	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
450	65321	331	340	350	360	369	379	389	398	408	34679	669	660	650	640	631	621	611	602	592
451	418	427	437	446	456	466	475	485	495	504	[illegible]	573	563	554	544	534	524	515	505	496
452	514	523	533	543	552	562	571	581	591	600	[illegible]	477	467	457	447	438	428	419	409	400
453	610	619	629	639	648	658	667	677	686	696	[illegible]	381	371	361	352	[illegible]	[illegible]	323	314	304
454	706	715	725	734	744	753	763	772	782	792	[illegible]	285	275	266	256	[illegible]	237	228	218	208
455	801	811	820	830	839	849	858	868	877	887	199	189	180	170	161	151	142	132	123	113
456	[illegible]	906	916	925	935	944	954	963	973	982	104	094	085	075	065	056	046	037	027	018
457	992	..1	.11	[illegible]	.30	.39	.49	.58	.68	.77	008	999	989	980	970	961	951	942	932	923
458	66086	096	105	115	124	134	143	153	162	172	33914	904	895	885	876	866	857	847	838	828
459	181	191	200	210	219	229	238	247	257	266	[illegible]	809	800	790	781	771	762	753	743	734
460	276	285	295	304	313	323	332	342	351	361	724	715	705	696	687	677	668	658	649	639
461	370	379	389	398	408	417	427	436	445	455	[illegible]	621	611	602	592	583	573	564	555	545
462	464	474	483	492	502	511	521	530	539	549	536	526	517	508	498	489	479	470	461	451
463	558	567	577	586	596	605	614	624	633	642	442	433	423	414	404	395	386	376	367	358
464	652	661	670	680	689	698	708	717	727	736	348	339	330	320	311	301	292	283	273	264
465	745	755	764	773	783	792	801	811	820	829	[illegible]	245	236	227	217	208	199	189	180	171
466	838	848	857	866	876	885	894	904	913	922	[illegible]	152	143	134	124	115	106	096	087	078
467	932	941	950	960	969	978	987	997	..6	.15	068	059	050	040	031	022	013	003	994	985
468	67025	034	043	052	062	071	080	089	099	108	32975	966	957	948	938	929	920	911	901	892
469	117	126	136	145	[illegible]	[illegible]	173	182	191	200	883	874	864	855	846	836	827	818	809	800
470	210	219	228	237	247	256	265	274	284	293	790	781	772	763	753	744	735	726	716	707
471	302	311	320	330	339	348	357	367	376	385	698	689	680	670	661	652	643	633	624	615
472	394	403	413	422	431	440	[illegible]	[illegible]	468	477	606	597	587	[illegible]	569	560	551	541	532	52
473	486	495	504	514	523	532	541	550	559	569	514	505	496	486	477	468	459	450	441	431
474	578	587	596	605	614	624	633	642	651	660	422	413	404	395	386	376	367	358	349	340
475	669	678	688	697	706	715	724	733	742	752	331	322	[illegible]	303	294	285	276	267	258	248
476	761	770	779	788	797	806	815	824	834	843	239	230	221	212	203	194	185	176	166	157
477	852	861	870	879	888	897	906	915	925	934	148	139	130	121	112	103	094	085	075	066
478	943	952	961	970	979	988	997	..6	.15	.24	057	048	039	030	021	012	003	994	985	976
479	68034	043	052	061	070	079	088	097	106	115	31966	957	948	939	930	921	912	903	894	885
480	124	133	142	151	160	169	178	187	196	205	876	867	858	849	840	831	822	813	804	795
481	214	223	233	242	251	260	269	278	287	296	786	777	767	758	749	740	731	722	713	704
482	305	314	323	332	341	350	359	368	377	386	695	686	677	668	659	650	641	632	623	614
483	[illegible]	404	413	422	431	440	449	458	467	476	605	596	587	578	569	560	551	542	[illegible]	524
484	484	493	502	511	520	529	[illegible]	547	556	565	516	507	498	489	480	471	462	453	[illegible]	[illegible]
485	574	583	592	601	610	619	628	637	646	655	426	417	408	399	390	381	372	363	354	345
486	664	673	681	690	699	708	717	726	735	744	336	327	319	310	301	292	283	274	265	256
487	753	762	771	780	789	797	806	815	824	833	247	238	229	220	211	203	194	185	176	167
488	842	851	860	869	878	886	895	904	913	922	158	149	140	131	122	114	105	096	087	078
489	931	[illegible]	[illegible]	957	966	975	984	993	..2	.11	069	060	051	043	034	025	016	007	998	989
490	69020	028	037	046	055	064	073	082	090	099	30980	972	963	954	945	936	927	918	910	901
491	108	117	126	135	143	152	161	170	179	188	892	883	874	865	857	848	839	830	821	812
492	196	205	214	223	232	241	249	258	267	276	804	795	786	777	768	759	751	742	733	724
493	285	293	302	311	320	329	337	346	355	364	715	707	698	689	680	671	663	654	645	636
494	373	381	390	399	408	417	425	434	443	452	627	619	610	601	592	583	575	566	557	548
495	460	469	478	487	496	[illegible]	513	522	531	539	540	531	522	518	504	496	487	478	469	461
496	548	557	566	574	583	592	601	609	618	627	452	443	434	426	417	408	399	391	382	373
497	636	644	653	662	671	679	688	697	705	714	364	356	347	338	329	321	312	303	295	286
498	723	732	740	749	758	766	775	784	793	801	277	268	260	251	242	234	225	216	207	199
499	810	819	827	836	845	853	862	871	880	888	190	181	173	164	155	147	138	129	120	112

	Logarithms.										Complements.									
N	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
500	69897	906	914	923	932	940	949	958	966	975	30103	094	086	077	068	060	051	042	034	025
501	983	992	..1	.10	.18	.27	.36	.44	.53	.62	016	008	999	990	982	973	964	956	947	938
502	70070	079	088	096	105	114	122	131	139	148	29930	921	912	904	895	886	878	869	861	852
503	157	165	174	183	191	200	209	217	226	234	843	835	826	817	809	800	791	783	774	766
504	243	252	260	269	277	286	295	303	312	320	757	748	740	731	723	714	705	697	688	680
505	329	338	346	355	363	372	381	389	398	406	671	662	654	645	637	628	619	611	602	594
506	415	424	432	441	449	458	466	475	484	492	585	576	568	559	551	542	534	525	516	508
507	501	509	518	526	535	544	552	561	569	578	499	491	482	474	465	456	448	439	431	422
508	586	595	603	612	621	629	638	646	655	663	414	405	397	388	379	371	362	354	345	337
509	672	680	689	697	706	714	723	731	740	748	328	320	311	303	294	286	277	269	260	252
510	757	765	774	783	791	800	808	817	825	834	243	235	226	217	209	200	192	183	175	166
511	842	851	859	868	876	885	893	901	910	918	158	149	141	132	124	115	107	099	090	082
512	927	935	944	952	961	969	978	986	995	..3	073	065	056	048	039	031	022	014	005	997
513	71012	020	029	037	046	054	063	071	079	088	28988	980	971	963	954	946	938	929	921	912
514	096	105	113	122	130	138	147	155	164	172	904	895	887	878	870	862	853	845	836	828
515	181	189	198	206	214	223	231	240	248	257	819	811	802	794	786	777	769	760	752	743
516	265	273	282	290	299	307	315	324	333	341	735	727	718	710	701	693	685	676	667	659
517	349	357	366	374	383	391	399	408	416	425	651	643	634	626	617	609	601	592	584	575
518	433	441	450	458	466	475	483	492	500	508	567	559	550	544	534	525	517	508	500	492
519	517	525	533	542	550	559	567	575	584	592	483	475	467	458	450	441	433	425	416	408
520	600	609	617	625	634	642	650	659	667	675	400	391	383	375	366	358	350	341	333	325
521	684	692	700	709	717	725	734	742	750	759	316	308	300	291	283	275	266	258	250	241
522	767	775	784	792	800	809	817	825	834	842	233	225	216	208	200	191	183	175	166	158
523	850	858	867	875	883	892	900	908	916	925	150	142	133	125	117	108	100	092	084	075
524	933	941	950	958	966	974	983	991	999	..8	067	059	050	042	034	026	017	009	001	992
525	72016	024	032	041	049	057	066	074	082	090	27984	976	968	959	951	943	935	926	918	910
526	099	107	115	123	132	140	148	156	165	173	901	893	885	877	868	860	852	844	835	827
527	181	189	197	206	214	222	230	239	247	255	819	811	803	794	786	778	770	761	753	745
528	263	272	280	288	296	304	313	321	329	337	737	728	720	712	704	696	687	679	671	663
529	346	354	362	370	378	387	395	403	411	419	654	646	638	630	622	613	605	597	589	581
530	428	436	444	452	460	468	477	485	493	501	572	564	556	548	540	532	523	515	507	499
531	509	518	526	534	542	550	558	567	575	583	491	482	474	466	458	450	442	433	425	417
532	591	599	607	616	624	632	640	648	656	665	409	401	393	384	376	368	360	352	344	335
533	673	681	689	697	705	713	722	730	738	746	327	319	311	303	295	287	278	270	262	254
534	754	762	770	778	787	795	803	811	819	827	246	238	230	222	213	205	197	189	181	173
535	835	843	852	860	868	876	884	892	900	908	165	157	148	140	132	124	116	108	100	092
536	916	925	933	941	949	957	965	973	981	989	084	075	067	059	051	043	035	027	019	011
537	997	..5	.14	.22	.30	.38	.46	.54	.62	.70	003	995	986	978	970	962	954	946	938	930
538	73078	086	094	102	110	119	127	135	143	151	26922	914	906	898	890	881	873	865	857	849
539	159	167	175	183	191	199	207	215	223	231	841	833	825	817	809	801	793	785	777	769
540	239	247	255	263	271	280	288	296	304	312	761	753	745	737	729	720	712	704	696	688
541	320	328	336	344	352	360	368	376	384	392	680	672	664	656	648	640	632	624	616	608
542	400	408	416	424	432	440	448	456	464	472	600	592	584	576	568	560	552	544	536	528
543	480	488	496	504	512	520	528	536	544	552	520	512	504	496	488	480	472	464	456	448
544	560	568	576	584	592	600	608	616	624	632	440	432	424	416	408	400	392	384	376	368
545	640	648	656	663	671	679	687	695	703	711	360	352	344	337	329	321	313	305	297	289
546	719	727	735	743	751	759	767	775	783	791	281	273	265	257	249	241	233	225	217	209
547	799	807	815	822	830	838	846	854	862	870	201	193	185	178	170	162	154	146	138	130
548	878	886	894	902	910	918	926	933	941	949	122	114	106	098	090	082	074	067	059	051
549	957	965	973	981	989	997	..5	.13	.20	.28	043	035	027	019	011	003	995	987	980	972

TABLE XVIII.

CONTAINING

THE LOGARITHMIC SINES AND COSINES

TO EVERY MINUTE OF THE QUADRANT,

WITH THEIR COMPLEMENTS,

AND DIFFERENCES ANSWERING TO EVERY 10″;

ALSO

THE LOGARITHMIC TANGENTS AND COTANGENTS,

WITH THEIR

DIFFERENCES CORRESPONDING TO THE SAME ARC OF 10″.

′	Sine	D. 10″.	Comp. sine	Cosine	D10″	Comp. cos.	Tangent	D. 10″.	Cotangent	′
0	Inf. neg.	Infinit.	Infinite.	10·0000000	0·0	0·0000000	Inf. neg.	Infinit	Infinite	60
1	6·4637261	501717	3·5362739	10·0000000	0·2	0·0000000	6·4637261	501717	13·5362739	59
2	6·7647561	293485	3·2352439	9·9999999	0·2	0·0000001	6·7647562	293485	13·2352438	58
3	6·9408473	208231	3·0591527	9·9999998	0·2	0·0000002	6·9408475	208231	13·0591525	57
4	7·0657860	161517	2·9342140	9·9999997	0·3	0·0000003	7·0657863	161517	12·9342137	56
5	7·1626960	131968	2·8373040	9·9999995	0·3	0·0000005	7·1626964	131969	12·8373036	55
6	7·2418771	111578	2·7581229	9·9999993	0·3	0·0000007	7·2418778	111578	12·7581222	54
7	7·3088239	96653	2·6911761	9·9999991	0·5	0·0000009	7·3088248	96653	12·6911752	53
8	7·3668157	85254	2·6331843	9·9999988	0·5	0·0000012	7·3668169	85254	12·6331831	52
9	7·4179681	76262	2·5820319	9·9999985	0·5	0·0000015	7·4179696	76263	12·5820304	51
10	7·4637255	68988	2·5362745	9·9999982	0·7	0·0000018	7·4637273	68988	12·5362727	50
11	7·5051181	62981	2·4948819	9·9999978	0·7	0·0000022	7·5051203	62981	12·4948797	49
12	7·5429065	57936	2·4570935	9·9999974	0·8	0·0000026	7·5429091	57937	12·4570909	48
13	7·5776684	53641	2·4223316	9·9999969	0·8	0·0000031	7·5776715	53642	12·4223285	47
14	7·6098530	49938	2·3901470	9·9999964	0·8	0·0000036	7·6098566	49939	12·3901434	46
15	7·6398160	46714	2·3601840	9·9999959	1·0	0·0000041	7·6398201	46715	12·3601799	45
16	7·6678445	43881	2·3321555	9·9999953	1·0	0·0000047	7·6678492	43882	12·3321508	44
17	7·6941733	41372	2·3058267	9·9999947	1·2	0·0000053	7·6941786	41373	12·3058214	43
18	7·7189966	39135	2·2810034	9·9999940	1·2	0·0000060	7·7190026	39136	12·2809974	42
19	7·7424775	37127	2·2575225	9·9999934	1·2	0·0000066	7·7424841	37128	12·2575159	41
20	7·7647537	35315	2·2352463	9·9999927	1·3	0·0000073	7·7647610	35316	12·2352390	40
21	7·7859427	33672	2·2140573	9·9999919	1·3	0·0000081	7·7859508	33673	12·2140492	39
22	7·8061458	32175	2·1938542	9·9999911	1·3	0·0000089	7·8061547	32176	12·1938453	38
23	7·8254507	30805	2·1745493	9·9999903	1·5	0·0000097	7·8254604	30807	12·1745396	37
24	7·8439338	29547	2·1560662	9·9999894	1·5	0·0000106	7·8439444	29549	12·1560556	36
25	7·8616623	28388	2·1383377	9·9999885	1·5	0·0000115	7·8616738	28390	12·1383262	35
26	7·8786953	27317	2·1213047	9·9999876	1·7	0·0000124	7·8787077	27318	12·1212923	34
27	7·8950854	26323	2·1049146	9·9999866	1·7	0·0000134	7·8950988	26325	12·1049012	33
28	7·9108793	25399	2·0891207	9·9999856	1·8	0·0000144	7·9108938	25401	12·0891062	32
29	7·9261190	24538	2·0738810	9·9999845	1·7	0·0000155	7·9261344	24540	12·0738656	31
30	7·9408419	23733	2·0591581	9·9999835	2·0	0·0000165	7·9408584	23735	12·0591416	30
31	7·9550819	22980	2·0449181	9·9999823	1·8	0·0000177	7·9550996	22982	12·0449004	29
32	7·9688698	2227.	2·0311302	9·9999812	2·0	0·0000188	7·9688886	22275	12·0311114	28
33	7·9822334	21608	2·0177666	9·9999800	2·0	0·0000200	7·9822534	21610	12·0177466	27
34	7·9951980	20981	2·0048020	9·9999788	2·2	0·0000212	7·9952192	20983	12·0047808	26
35	8·0077867	20390	1·9922133	9·9999775	2·2	0·0000225	8·0078092	20392	11·9921908	25
36	8·0200207	19831	1·9799793	9·9999762	2·3	0·0000238	8·0200445	19833	11·9799555	24
37	8·0319195	19302	1·9680805	9·9999748	2·2	0·0000252	8·0319446	19305	11·9680554	23
38	8·0435009	18801	1·9564991	9·9999735	2·3	0·0000265	8·0435274	18803	11·9564726	22
39	8·0547814	18325	1·9452186	9·9999721	2·5	0·0000279	8·0548094	18327	11·9451906	21
40	8·0657763	17872	1·9342237	9·9999706	2·5	0·0000294	8·0658057	17875	11·9341943	20
41	8·0764997	17441	1·9235003	9·9999691	2·5	0·0000309	8·0765306	17444	11·9234694	19
42	8·0869646	17031	1·9130354	9·9999676	2·7	0·0000324	8·0869970	17034	11·9130030	18
43	8·0971832	16636	1·9028168	9·9999660	2·7	0·0000340	8·0972172	16642	11·9027828	17
44	8·1071669	16265	1·8928331	9·9999644	2·7	0·0000356	8·1072025	16268	11·8927975	16
45	8·1169262	15908	1·8830738	9·9999628	2·8	0·0000372	8·1169634	15911	11·8830366	15
46	8·1264710	15566	1·8735290	9·9999611	2·8	0·0000389	8·1265099	15568	11·8734901	14
47	8·1358104	15238	1·8641896	9·9999594	2·8	0·0000406	8·1358510	15241	11·8641490	13
48	8·1449532	14924	1·8550468	9·9999577	3·0	0·0000423	8·1449956	14927	11·8550044	12
49	8·1539075	14622	1·8460925	9·9999559	3·0	0·0000441	8·1539516	14625	11·8460484	11
50	8·1626808	14333	1·8373192	9·9999541	3·2	0·0000459	8·1627267	14336	11·8372733	10
51	8·1712804	14054	1·8287196	9·9999522	3·2	0·0000478	8·1713282	14057	11·8286718	9
52	8·1797129	13786	1·8202871	9·9999503	3·2	0·0000497	8·1797626	13790	11·8202374	8
53	8·1879848	13529	1·8120152	9·9999484	3·3	0·0000516	8·1880364	13532	11·8119636	7
54	8·1961020	13280	1·8038980	9·9999464	3·3	0·0000536	8·1961556	13284	11·8038444	6
55	8·2040703	13041	1·7959297	9·9999444	3·3	0·0000556	8·2041259	13044	11·7958741	5
56	8·2118949	12810	1·7881051	9·9999424	3·5	0·0000576	8·2119526	12814	11·7880474	4
57	8·2195811	12587	1·7804189	9·9999403	3·5	0·0000597	8·2196408	12591	11·7803592	3
58	8·2271335	12372	1·7728665	9·9999382	3·7	0·0000618	8·2271953	12376	11·7728047	2
59	8·2345568	12164	1·7654432	9·9999360	3·7	0·0000640	8·2346208	12168	11·7653792	1
60	8·2418553		1·7581447	9·9999338		0·0000662	8·2419215		11·7580785	0
′	Cosine	D. 10″.	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D. 10″.	Tangent	′

′	Sine	D. 10″	Comp.sin.	Cosine	D. 10″	Comp.cos.	Tangent	D. 10″	Cotangent	′
0	8·2418553	11963	1·7581447	9·9999338	3·7	0·0000662	8·2419215	11967	11·7580785	60
1	8·2490332	11768	1·7509668	9·9999316	3·7	0·0000684	8·2491015	11772	11·7508985	59
2	8·2560943	11580	1·7439057	9·9999294	3·8	0·0000706	8·2561649	11584	11·7438351	58
3	8·2630424	11398	1·7369576	9·9999271	4·0	0·0000729	8·2631153	11402	11·7368847	57
4	8·2698810	11221	1·7301190	9·9999247	3·8	0·0000753	8·2699563	11225	11·7300437	56
5	8·2766136	11050	1·7233864	9·9999224	4·0	0·0000776	8·2766912	11054	11·7233088	55
6	8·2832434	10883	1·7167566	9·9999200	4·2	0·0000800	8·2833234	10887	11·7166766	54
7	8·2897734	10722	1·7102266	9·9999175	4·2	0·0000825	8·2898559	10726	11·7101441	53
8	8·2962067	10565	1·7037933	9·9999150	4·2	0·0000850	8·2962917	10570	11·7037083	52
9	8·3025460	10413	1·6974540	9·9999125	4·2	0·0000875	8·3026335	10418	11·6973665	51
10	8·3087941	10266	1·6912059	9·9999100	4·3	0·0000900	8·3088842	10270	11·6911158	50
11	8·3149536	10122	1·6850464	9·9999074	4·5	0·0000926	8·3150462	10126	11·6849536	49
12	8·3210269	9982	1·6789731	9·9999047	4·3	0·0000953	8·3211221	9987	11·6788779	48
13	8·3270163	9847	1·6729837	9·9999021	4·5	0·0000979	8·3271143	9851	11·6728857	47
14	8·3329243	9714	1·6670757	9·9998994	4·7	0·0001006	8·3330249	9719	11·6669751	46
15	8·3387529	9586	1·6612471	9·9998966	4·5	0·0001034	8·3388563	9590	11·6611437	45
16	8·3445043	9460	1·6554957	9·9998939	4·7	0·0001061	8·3446105	9465	11·6553895	44
17	8·3501805	9338	1·6498195	9·9998911	4·8	0·0001069	8·3502895	9343	11·6497105	43
18	8·3557835	9219	1·6442165	9·9998882	4·8	0·0001118	8·3558953	9224	11·6441047	42
19	8·3613150	9103	1·6386850	9·9998853	4·8	0·0001147	8·3614297	9108	11·6385703	41
20	8·3667759	8990	1·6332231	9·9998824	5·0	0·0001176	8·3668945	8995	11·6331055	40
21	8·3721710	8880	1·6278290	9·9998794	5·0	0·0001206	8·3722915	8885	11·6277085	39
22	8·3774988	8772	1·6225012	9·9998764	5·0	0·0001236	8·3776223	8777	11·6223777	38
23	8·3827620	8667	1·6172380	9·9998734	5·2	0·0001266	8·3828886	8672	11·6171114	37
24	8·3879622	8564	1·6120378	9·9998703	5·2	0·0001297	8·3880918	8570	11·6119082	36
25	8·3931006	8464	1·6068994	9·9998672	5·2	0·0001328	8·3932336	8469	11·6067664	35
26	8·3981793	8366	1·6018207	9·9998641	5·3	0·0001359	8·3983152	8371	11·6016848	34
27	8·4031990	8271	1·5968010	9·9998609	5·3	0·0001391	8·4033381	8276	11·5966619	33
28	8·4081614	8177	1·5918386	9·9998577	5·5	0·0001423	8·4083037	8182	11·5916963	32
29	8·4130676	8086	1·5869324	9·9998544	5·5	0·0001456	8·4132132	8091	11·5867868	31
30	8·4179190	7996	1·5820810	9·9998512	5·7	0·0001488	8·4180679	8002	11·5819321	30
31	8·4227168	7909	1·5772832	9·9998478	5·5	0·0001522	8·4228690	7914	11·5771310	29
32	8·4274621	7823	1·5725379	9·9998445	5·7	0·0001555	8·4276176	7829	11·5723824	28
33	8·4321561	7740	1·5678439	9·9998411	5·8	0·0001589	8·4323150	7745	11·5676850	27
34	8·4367999	7657	1·5632001	9·9998376	5·7	0·0001624	8·4369622	7663	11·5630378	26
35	8·4413944	7577	1·5586056	9·9998342	6·0	0·0001658	8·4415603	7583	11·5584397	25
36	8·4459409	7499	1·5540591	9·9998306	5·8	0·0001694	8·4461103	7505	11·5538897	24
37	8·4504402	7422	1·5495598	9·9998271	6·0	0·0001729	8·4506131	7428	11·5493869	23
38	8·4548934	7346	1·5451066	9·9998235	6·0	0·0001765	8·4550699	7352	11·5449301	22
39	8·4593013	7273	1·5406987	9·9998199	6·2	0·0001801	8·4594814	7279	11·5405186	21
40	8·4636649	7200	1·5363351	9·9998162	6·2	0·0001838	8·4638486	7206	11·5361514	20
41	8·4679850	7129	1·5320150	9·9998125	6·2	0·0001875	8·4681725	7135	11·5318275	19
42	8·4722626	7060	1·5277374	9·9998088	6·3	0·0001912	8·4724538	7066	11·5275462	18
43	8·4764984	6991	1·5235016	9·9998050	6·3	0·0001950	8·4766933	6998	11·5233067	17
44	8·4806932	6924	1·5193068	9·9998012	6·3	0·0001988	8·4808920	6931	11·5191080	16
45	8·4848479	6859	1·5151521	9·9997974	6·5	0·0002026	8·4850505	6865	11·5149495	15
46	8·4889632	6794	1·5110368	9·9997935	6·5	0·0002065	8·4891696	6801	11·5108304	14
47	8·4930398	6731	1·5069602	9·9997896	6·5	0·0002104	8·4932502	6738	11·5067498	13
48	8·4970784	6669	1·5029216	9·9997856	6·5	0·0002144	8·4972928	6676	11·5027072	12
49	8·5010798	6608	1·4989202	9·9997817	6·8	0·0002184	8·5012982	6615	11·4987018	11
50	8·5050447	6548	1·4949553	9·9997776	6·7	0·0002224	8·5052671	6555	11·4947329	10
51	8·5089736	6490	1·4910264	9·9997736	6·8	0·0002264	8·5092001	6496	11·4907999	9
52	8·5128673	6432	1·4871327	9·9997695	7·0	0·0002305	8·5130978	6439	11·4869022	8
53	8·5167264	6375	1·4832736	9·9997653	6·8	0·0002347	8·5169610	6382	11·4830390	7
54	8·5205514	6319	1·4794486	9·9997612	7·0	0·0002388	8·5207902	6326	11·4792098	6
55	8·5243430	6264	1·4756570	9·9997570	7·2	0·0002430	8·5245860	6272	11·4754140	5
56	8·5281017	6211	1·4718983	9·9997527	7·2	0·0002473	8·5283490	6218	11·4716510	4
57	8·5318281	6158	1·4681719	9·9997484	7·2	0·0002516	8·5320797	6165	11·4679203	3
58	8·5355228	6106	1·4644772	9·9997441	7·2	0·0002559	8·5357787	6113	11·4642213	2
59	8·5391863	6055	1·4608137	9·9997398	7·3	0·0002602	8·5394466	6062	11·4605534	1
60	8·5428192		1·4571808	9·9997354		0·0002646	8·5430838		11·4569162	0
′	Cosine	D. 10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D. 10″	Tangent	′

′	Sine	D10″	Comp.sec.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	8·5428192	6004	1·4571808	9·9997354	7·5	0·0002646	8·5430838	6012	11·4569162	60
1	8·5464218	5956	1·4535782	9·9997309	7·3	0·0002691	8·5466909	5962	11·4533091	59
2	8·5499948	5906	1·4500052	9·9997265	7·5	0·0002735	8·5502683	5914	11·4497317	58
3	8·5535386	5858	1·4464614	9·9997220	7·7	0·0002780	8·5538166	5866	11·4461834	57
4	8·5570536	5811	1·4429464	9·9997174	7·7	0·0002826	8·5573362	5819	11·4426638	56
5	8·5605404	5765	1·4394596	9·9997128	7·7	0·0002872	8·5608276	5773	11·4391724	55
6	8·5639994	5719	1·4360006	9·9997082	7·7	0·0002918	8·5642912	5727	11·4357088	54
7	8·5674310	5674	1·4325690	9·9997036	7·8	0·0002964	8·5677275	5682	11·4322725	53
8	8·5708357	5630	1·4291643	9·9996989	7·8	0·0003011	8·5711368	5638	11·4288632	52
9	8·5742139	5587	1·4257861	9·9996942	8·0	0·0003058	8·5745197	5595	11·4254803	51
10	8·5775660	5544	1·4224340	9·9996894	8·0	0·0003106	8·5778766	5552	11·4221234	50
11	8·5808923	5502	1·4191077	9·9996846	8·0	0·0003154	8·5812077	5510	11·4187923	49
12	8·5841933	5460	1·4158067	9·9996798	8·2	0·0003202	8·5845136	5468	11·4154864	48
13	8·5874694	5419	1·4125306	9·9996749	8·2	0·0003251	8·5877945	5427	11·4122055	47
14	8·5907209	5379	1·4092791	9·9996700	8·3	0·0003300	8·5910509	5387	11·4089491	46
15	8·5939483	5339	1·4060517	9·9996650	8·2	0·0003350	8·5942832	5347	11·4057168	45
16	8·5971517	5300	1·4028483	9·9996601	8·5	0·0003399	8·5974917	5308	11·4025083	44
17	8·6003317	5261	1·3996683	9·9996550	8·5	0·0003450	8·6006767	5270	11·3993233	43
18	8·6034886	5223	1·3965114	9·9996500	8·5	0·0003500	8·6038386	5232	11·3961614	42
19	8·6066226	5186	1·3933774	9·9996449	8·5	0·0003551	8·6069777	5194	11·3930223	41
20	8·6097341	5149	1·3902659	9·9996398	8·7	0·0003602	8·6100943	5158	11·3899057	40
21	8·6128235	5112	1·3871765	9·9996346	8·7	0·0003654	8·6131889	5121	11·3868111	39
22	8·6158910	5076	1·3841090	9·9996294	8·7	0·0003706	8·6162616	5085	11·3837384	38
23	8·6189369	5041	1·3810631	9·9996242	8·8	0·0003758	8·6193127	5050	11·3806873	37
24	8·6219616	5006	1·3780384	9·9996189	8·8	0·0003811	8·6223427	5015	11·3776573	36
25	8·6249653	4972	1·3750347	9·9996136	9·0	0·0003864	8·6253518	4981	11·3746482	35
26	8·6279484	4938	1·3720516	9·9996082	9·0	0·0003918	8·6283402	4947	11·3716598	34
27	8·6309111	4904	1·3690889	9·9996028	9·0	0·0003972	8·6313083	4913	11·3686917	33
28	8·6338537	4871	1·3661463	9·9995974	9·2	0·0004026	8·6342563	4880	11·3657437	32
29	8·6367764	4839	1·3632236	9·9995919	9·0	0·0004081	8·6371845	4848	11·3628155	31
30	8·6396796	4806	1·3603204	9·9995865	9·3	0·0004135	8·6400931	4816	11·3599069	30
31	8·6425634	4775	1·3574366	9·9995809	9·3	0·0004191	8·6429825	4784	11·3570175	29
32	8·6454282	4743	1·3545718	9·9995753	9·3	0·0004247	8·6458528	4753	11·3541472	28
33	8·6482742	4712	1·3517258	9·9995697	9·3	0·0004303	8·6487044	4722	11·3512956	27
34	8·6511016	4682	1·3488984	9·9995641	9·5	0·0004359	8·6515375	4691	11·3484625	26
35	8·6539107	4652	1·3460893	9·9995584	9·5	0·0004416	8·6543522	4661	11·3456478	25
36	8·6567017	4622	1·3432983	9·9995527	9·6	0·0004473	8·6571490	4631	11·3428510	24
37	8·6594748	4592	1·3405252	9·9995469	9·6	0·0004531	8·6599279	4602	11·3400721	23
38	8·6622303	4563	1·3377697	9·9995411	9·6	0·0004589	8·6626891	4573	11·3373109	22
39	8·6649684	[illegible]	1·3350316	9·9995353	9·6	0·0004647	8·6654331	4544	11·3345669	21
40	8·6676893	4506	1·3323107	9·9995295	9·8	0·0004705	8·6681598	4516	11·3318402	20
41	8·6703932	4479	1·3296068	9·9995236	10·0	0·0004764	8·6708697	4488	11·3291303	19
42	8·6730804	4451	1·3269196	9·9995176	10·0	0·0004824	8·6735628	4461	11·3264372	18
43	8·6757510	4424	1·3242490	9·9995116	10·0	0·0004884	8·6762393	4434	11·3237607	17
44	8·6784053	4397	1·3215948	9·9995056	10·0	0·0004944	8·6788996	4407	11·3211004	16
45	8·6810438	4370	1·3189567	9·9994996	10·2	0·0005004	8·6815437	4380	11·3184563	15
46	8·6836654	4344	1·3163346	9·9994935	10·2	0·0005065	8·6841719	4354	11·3158281	14
47	8·6862718	4318	1·3137282	9·9994874	10·3	0·0005126	8·6867844	4328	11·3132156	13
48	8·6888625	4292	1·3111375	9·9994812	10·3	0·0005188	8·6893813	4303	11·3106187	12
49	8·6914379	4267	1·3085621	9·9994750	10·3	0·0005250	8·6919629	4277	11·3080371	11
50	8·6939980	4242	1·3060020	9·9994688	10·5	0·0005312	8·6945292	4252	11·3054708	10
51	8·6965431	4217	1·3034569	9·9994625	10·5	0·0005375	8·6970806	4228	11·3029194	9
52	8·6990734	4192	1·3009266	9·9994562	10·7	0·0005438	8·6996172	4203	11·3003828	8
53	8·7015889	4168	1·2984111	9·9994498	10·5	0·0005502	8·7021390	4179	11·2978610	7
54	8·7040899	4144	1·2959101	9·9994435	10·8	0·0005565	8·7046465	4155	11·2953535	6
55	8·7065766	4121	1·2934234	9·9994370	10·7	0·0005630	8·7071395	4132	11·2928605	5
56	8·7090490	4097	1·2909510	9·9994306	10·8	0·0005694	8·7096185	4108	11·2903815	4
57	8·7115075	4074	1·2884925	9·9994241	10·8	0·0005759	8·7120834	4085	11·2879166	3
58	8·7139520	4051	1·2860480	9·9994176	11·0	0·0005824	8·7145345	4062	11·2854655	2
59	8·7163829	4029	1·2836171	9·9994110	11·0	0·0005890	8·7169719	4040	11·2830281	1
60	8·7188002		1·2811998	9·9994044		0·0005956	8·7193958		11·2806042	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

3 Deg.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	8·7188002	4006	1·2811998	9·9994044	11·0	0·0005956	8·7193958	4017	11·2806042	60
1	8·7212040	3984	1·2787960	9·9993978	11·2	0·0006022	8·7218063	3995	11·2781937	59
2	8·7235946	3962	1·2764054	9·9993911	11·2	0·0006089	8·7242035	3974	11·2757965	58
3	8·7259721	3941	1·2740279	9·9993844	11·3	0·0006156	8·7265877	3952	11·2734123	57
4	8·7283366	3919	1·2716634	9·9993776	11·3	0·0006224	8·7289589	3931	11·2710411	56
5	8·7306882	3898	1·2693118	9·9993708	11·3	0·0006292	8·7313174	3909	11·2686826	55
6	8·7330272	3877	1·2669728	9·9993640	11·3	0·0006360	8·7336631	3889	11·2663369	54
7	8·7353535	3857	1·2646465	9·9993572	11·5	0·0006428	8·7359964	3868	11·2640036	53
8	8·7376675	3836	1·2623325	9·9993503	11·5	0·0006497	8·7383172	3848	11·2616828	52
9	8·7399691	3816	1·2600309	9·9993433	11·5	0·0006567	8·7406258	3827	11·2593742	51
10	8·7422586	3796	1·2577414	9·9993364	11·8	0·0006636	8·7429222	3807	11·2570778	50
11	8·7445360	3776	1·2554640	9·9993293	11·7	0·0006707	8·7452067	3787	11·2547933	49
12	8·7468015	3756	1·2531985	9·9993223	11·8	0·0006777	8·7474792	3768	11·2525208	48
13	8·7490553	3737	1·2509447	9·9993152	11·8	0·0006848	8·7497400	3749	11·2502600	47
14	8·7512973	3717	1·2487027	9·9993081	12·0	0·0006919	8·7519892	3729	11·2480108	46
15	8·7535278	3698	1·2464722	9·9993009	12·0	0·0006991	8·7542269	3710	11·2457731	45
16	8·7557469	3679	1·2442531	9·9992938	12·0	0·0007062	8·7564531	3692	11·2435469	44
17	8·7579546	3661	1·2420454	9·9992865	12·0	0·0007135	8·7586681	3673	11·2413319	43
18	8·7601512	3642	1·2398488	9·9992793	12·2	0·0007207	8·7608719	3655	11·2391281	42
19	8·7623366	3624	1·2376634	9·9992720	12·3	0·0007280	8·7630647	3636	11·2369353	41
20	8·7645111	3606	1·2354889	9·9992646	12·3	0·0007354	8·7652465	3618	11·2347535	40
21	8·7666747	3588	1·2333253	9·9992572	12·3	0·0007428	8·7674175	3600	11·2325825	39
22	8·7688275	3570	1·2311725	9·9992498	12·3	0·0007502	8·7695777	3583	11·2304223	38
23	8·7709697	3553	1·2290303	9·9992424	12·5	0·0007576	8·7717274	3565	11·2282726	37
24	8·7731014	3535	1·2268986	9·9992349	12·5	0·0007651	8·7738665	3548	11·2261335	36
25	8·7752226	3518	1·2247774	9·9992274	12·7	0·0007726	8·7759952	3531	11·2240048	35
26	8·7773334	3501	1·2226666	9·9992198	12·7	0·0007802	8·7781136	3514	11·2218864	34
27	8·7794340	3484	1·2205660	9·9992122	12·7	0·0007878	8·7802218	3497	11·2197782	33
28	8·7815244	3467	1·2184756	9·9992046	12·8	0·0007954	8·7823199	3480	11·2176801	32
29	8·7836048	3451	1·2163952	9·9991969	12·8	0·0008031	8·7844079	3464	11·2155921	31
30	8·7856753	3434	1·2143247	9·9991892	12·8	0·0008108	8·7864861	3447	11·2135139	30
31	8·7877359	3418	1·2122641	9·9991815	13·0	0·0008185	8·7885544	3431	11·2114456	29
32	8·7897867	3402	1·2102133	9·9991737	13·0	0·0008263	8·7906130	3415	11·2093870	28
33	8·7918278	3386	1·2081722	9·9991659	13·2	0·0008341	8·7926620	3399	11·2073380	27
34	8·7938591	3370	1·2061406	9·9991580	13·2	0·0008420	8·7947011	3383	11·2052986	26
35	8·7958811	3354	1·2041186	9·9991501	13·2	0·0008499	8·7967313	3368	11·2032687	25
36	8·7978941	3339	1·2021059	9·9991422	13·3	0·0008578	8·7987519	3352	11·2012481	24
37	8·7998974	3323	1·2001026	9·9991342	13·3	0·0008658	8·8007632	3337	11·1992368	23
38	8·8018915	3308	1·1981085	9·9991262	13·3	0·0008738	8·8027653	3322	11·1972347	22
39	8·8038764	3293	1·1961236	9·9991182	13·5	0·0008818	8·8047583	3306	11·1952417	21
40	8·8058523	3278	1·1941477	9·9991101	13·5	0·0008899	8·8067422	3292	11·1932578	20
41	8·8078192	3263	1·1921808	9·9991020	13·7	0·0008980	8·8087172	3277	11·1912828	19
42	8·8097772	3249	1·1902228	9·9990938	13·7	0·0009062	8·8106834	3262	11·1893166	18
43	8·8117264	3234	1·1882736	9·9990856	13·7	0·0009144	8·8126407	3248	11·1873593	17
44	8·8136668	3219	1·1863332	9·9990774	13·8	0·0009226	8·8145894	3233	11·1854106	16
45	8·8155985	3205	1·1844015	9·9990691	13·8	0·0009309	8·8165294	3219	11·1834706	15
46	8·8175217	3191	1·1824783	9·9990608	13·8	0·0009392	8·8184608	3205	11·1815392	14
47	8·8194363	3177	1·1805637	9·9990525	14·0	0·0009475	8·8203838	3191	11·1796162	13
48	8·8213425	3163	1·1786575	9·9990441	14·0	0·0009559	8·8222984	3177	11·1777016	12
49	8·8232404	3149	1·1767596	9·9990357	14·0	0·0009643	8·8242046	3163	11·1757954	11
50	8·8251299	3135	1·1748701	9·9990273	14·2	0·0009727	8·8261026	3150	11·1738974	10
51	8·8270112	3122	1·1729888	9·9990188	14·2	0·0009812	8·8279924	3136	11·1720076	9
52	8·8288844	3108	1·1711156	9·9990103	14·3	0·0009897	8·8298741	3123	11·1701259	8
53	8·8307495	3095	1·1692505	9·9990017	14·3	0·0009983	8·8317478	3109	11·1682522	7
54	8·8326066	3082	1·1673934	9·9989931	14·3	0·0010069	8·8336134	3096	11·1663866	6
55	8·8344557	3069	1·1655443	9·9989845	14·5	0·0010155	8·8354712	3083	11·1645288	5
56	8·8362969	3056	1·1637031	9·9989758	14·5	0·0010242	8·8373211	3070	11·1626789	4
57	8·8381304	3043	1·1618696	9·9989671	14·5	0·0010329	8·8391632	3057	11·1608367	3
58	8·8399561	3030	1·1600439	9·9989584	14·7	0·0010416	8·8409977	3045	11·1590023	2
59	8·8417741	3017	1·1582259	9·9989496	14·7	0·0010504	8·8428245	3032	11·1571755	1
60	8·8435845		1·1564155	9·9989408		0·0010592	8·8446437		11·5553563	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

4 Deg. Tab. 18.

′	Sine.	D10″	Comp.sin.	Cosine.	D10″	Comp.cos.	Tangent.	D10″	Cotangent.	′
0	8·8435845	3005	1·1564155	9·9989408	14·8	0·0010592	8·8446437	3019	11·1553563	60
1	8·8453874	2992	1·1546126	9·9989319	14·8	0·0010681	8·8464554	3007	11·1535446	59
2	8·8471827	2980	1·1528173	9·9989230	14·8	0·0010770	8·8482597	2995	11·1517403	58
3	8·8489707	2967	1·1510293	9·9989141	14·8	0·0010859	8·8500566	2982	11·1499434	57
4	8·8507512	2955	1·1492488	9·9989052	15·0	0·0010948	8·8518461	2970	11·1481539	56
5	8·8525245	2943	1·1474755	9·9988962	15·2	0·0011038	8·8536283	2958	11·1463717	55
6	8·8542905	2931	1·1457095	9·9988871	15·2	0·0011129	8·8554034	2946	11·1445966	54
7	8·8560493	2919	1·1439507	9·9988780	15·2	0·0011220	8·8571713	2935	11·1428287	53
8	8·8578010	2908	1·1421990	9·9988689	15·2	0·0011311	8·8589321	2923	11·1410679	52
9	8·8595457	2896	1·1404543	9·9988598	15·3	0·0011402	8·8606859	2911	11·1393141	51
10	8·8612833	2884	1·1387167	9·9988506	15·3	0·0011494	8·8624327	2900	11·1375673	50
11	8·8630139	2873	1·1369861	9·9988414	15·5	0·0011586	8·8641725	2888	11·1358275	49
12	8·8647376	2861	1·1352624	9·9988321	15·5	0·0011679	8·8659055	2877	11·1340945	48
13	8·8664545	2850	1·1335455	9·9988228	15·5	0·0011772	8·8676317	2866	11·1323683	47
14	8·8681646	2839	1·1318354	9·9988135	15·7	0·0011865	8·8693511	2854	11·1306489	46
15	8·8698680	2828	1·1301320	9·9988041	15·7	0·0011959	8·8710638	2843	11·1289362	45
16	8·8715646	2817	1·1284354	9·9987947	15·7	0·0012053	8·8727699	2832	11·1272301	44
17	8·8732546	2806	1·1267454	9·9987853	15·8	0·0012147	8·8744694	2821	11·1255306	43
18	8·8749381	2795	1·1250619	9·9987758	15·8	0·0012242	8·8761623	2811	11·1238377	42
19	8·8766150	2784	1·1233850	9·9987663	16·0	0·0012337	8·8778487	2800	11·1221513	41
20	8·8782854	2773	1·1217146	9·9987567	16·0	0·0012433	8·8795286	2789	11·1204714	40
21	8·8799493	2763	1·1200507	9·9987471	16·0	0·0012529	8·8812022	2779	11·1187978	39
22	8·8816069	2752	1·1183931	9·9987375	16·2	0·0012625	8·8828694	2768	11·1171306	38
23	8·8832581	2742	1·1167419	9·9987278	16·2	0·0012722	8·8845303	2758	11·1154697	37
24	8·8849031	2731	1·1150969	9·9987181	16·2	0·0012819	8·8861850	2747	11·1138150	36
25	8·8865418	2721	1·1134582	9·9987084	16·3	0·0012916	8·8878334	2737	11·1121666	35
26	8·8881743	2711	1·1118257	9·9986986	16·3	0·0013014	8·8894757	2727	11·1105243	34
27	8·8898007	2700	1·1101993	9·9986888	16·3	0·0013112	8·8911119	2717	11·1088881	33
28	8·8914209	2690	1·1085791	9·9986790	16·5	0·0013210	8·8927420	2707	11·1072580	32
29	8·8930351	2680	1·1069649	9·9986691	16·5	0·0013309	8·8943660	2697	11·1056340	31
30	8·8946433	2670	1·1053567	9·9986591	16·5	0·0013409	8·8959842	2687	11·1040158	30
31	8·8962455	2660	1·1037545	9·9986492	16·7	0·0013508	8·8975963	2677	11·1024037	29
32	8·8978418	2651	1·1021582	9·9986392	16·7	0·0013608	8·8992026	2667	11·1007974	28
33	8·8994322	2641	1·1005678	9·9986292	16·8	0·0013708	8·9008030	2658	11·0991970	27
34	8·9010168	2631	1·0989832	9·9986191	16·8	0·0013809	8·9023977	2648	11·0976023	26
35	8·9025955	2622	1·0974045	9·9986090	17·0	0·0013910	8·9039866	2638	11·0960134	25
36	8·9041685	2612	1·0958315	9·9985988	17·0	0·0014012	8·9055697	2629	11·0944303	24
37	8·9057358	2603	1·0942642	9·9985886	17·0	0·0014114	8·9071472	2620	11·0928528	23
38	8·9072975	2593	1·0927025	9·9985784	17·0	0·0014216	8·9087190	2610	11·0912810	22
39	8·9088535	2584	1·0911465	9·9985682	17·2	0·0014318	8·9102853	2601	11·0897147	21
40	8·9104039	2575	1·0895961	9·9985579	17·2	0·0014421	8·9118460	2592	11·0881540	20
41	8·9119487	2566	1·0880513	9·9985475	17·3	0·0014525	8·9134012	2583	11·0865988	19
42	8·9134881	2556	1·0865119	9·9985372	17·3	0·0014628	8·9149509	2574	11·0850491	18
43	8·9150219	2547	1·0849781	9·9985268	17·5	0·0014732	8·9164952	2565	11·0835048	17
44	8·9165504	2538	1·0834496	9·9985163	17·5	0·0014837	8·9180340	2556	11·0819660	16
45	8·9180734	2529	1·0819266	9·9985058	17·5	0·0014942	8·9195675	2547	11·0804325	15
46	8·9195911	2520	1·0804089	9·9984953	17·5	0·0015047	8·9210957	2538	11·0789043	14
47	8·9211034	2512	1·0788966	9·9984848	17·7	0·0015152	8·9226186	2529	11·0773814	13
48	8·9226105	2503	1·0773895	9·9984742	17·7	0·0015258	8·9241363	2521	11·0758637	12
49	8·9241123	2494	1·0758877	9·9984636	17·8	0·0015364	8·9256487	2512	11·0743513	11
50	8·9256089	2486	1·0743911	9·9984529	17·8	0·0015471	8·9271560	2503	11·0728440	10
51	8·9271003	2477	1·0728997	9·9984422	17·8	0·0015578	8·9286581	2495	11·0713419	9
52	8·9285866	2469	1·0714134	9·9984315	18·0	0·0015685	8·9301552	2486	11·0698448	8
53	8·9300678	2460	1·0699322	9·9984207	18·0	0·0015793	8·9316471	2478	11·0683529	7
54	8·9315439	2452	1·0684561	9·9984099	18·2	0·0015901	8·9331340	2470	11·0668660	6
55	8·9330150	2443	1·0669850	9·9983990	18·2	0·0016010	8·9346160	2461	11·0653840	5
56	8·9344811	2435	1·0655189	9·9983881	18·2	0·0016119	8·9560929	2453	11·0639071	4
57	8·9359422	2427	1·0640578	9·9983772	18·2	0·0016228	8·9375650	2445	11·0624350	3
58	8·9373983	2419	1·0626017	9·9983663	18·3	0·0016337	8·9390321	2437	11·0609679	2
59	8·9388496	2411	1·0611504	9·9983553	18·3	0·0016447	8·9404944	2429	11·0595056	1
60	8·9402960		1·0597040	9·9983442		0·0016558	8·9419518		11·0580482	0
′	Cosine.	D10″	Comp.cos.	Sine.	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

5 Deg. Tab. 18.

′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	8·9402960	2403	1·0597040	9·9983442	18·3	0·0016558	8·9419518	2421	11·0580482	60
1	8·9417376	2395	1·0582624	9·9983332	18·7	0·0016668	8·9434044	2418	11·0565956	59
2	8·9431743	2387	1·0568257	9·9983220	18·5	0·0016780	8·9448523	2405	11·0551477	58
3	8·9446063	2379	1·0553937	9·9983109	18·7	0·0016891	8·9462954	2397	11·0537046	57
4	8·9460335	2371	1·0539665	9·9982997	18·7	0·0017003	8·9477338	2390	11·0522662	56
5	8·9474561	2363	1·0525439	9·9982885	18·8	0·0017115	8·9491676	2382	11·0508324	55
6	8·9488739	2355	1·0511261	9·9982772	18·7	0·0017228	8·9505967	2374	11·0494033	54
7	8·9502871	2348	1·0497129	9·9982660	19·0	0·0017340	8·9520211	2366	11·0479789	53
8	8·9516957	2340	1·0483043	9·9982546	18·8	0·0017454	8·9534410	2359	11·0465590	52
9	8·9530996	2332	1·0469004	9·9982433	19·2	0·0017567	8·9548564	2351	11·0451436	51
10	8·9544991	2325	1·0455009	9·9982318	19·0	0·0017682	8·9562672	2344	11·0437328	50
11	8·9558940	2317	1·0441060	9·9982204	19·2	0·0017796	8·9576735	2336	11·0423265	49
12	8·9572843	2310	1·0427157	9·9982089	19·2	0·0017911	8·9590754	2329	11·0409246	48
13	8·9586703	2302	1·0413297	9·9981974	19·2	0·0018026	8·9604728	2322	11·0395272	47
14	8·9600517	2295	1·0399483	9·9981859	19·3	0·0018141	8·9618659	2314	11·0381341	46
15	8·9614288	2288	1·0385712	9·9981743	19·5	0·0018257	8·9632545	2307	11·0367455	45
16	8·9628014	2280	1·0371986	9·9981626	19·3	0·0018374	8·9646388	2300	11·0353612	44
17	8·9641697	2273	1·0358303	9·9981510	19·5	0·0018490	8·9660188	2293	11·0339812	43
18	8·9655337	2266	1·0344663	9·9981393	19·7	0·0018607	8·9673944	2286	11·0326056	42
19	8·9668934	2259	1·0331066	9·9981275	19·5	0·0018725	8·9687658	2279	11·0312342	41
20	8·9682487	2252	1·0317513	9·9981158	19·7	0·0018842	8·9701330	2272	11·0298670	40
21	8·9695999	2245	1·0304001	9·9981040	19·8	0·0018960	8·9714959	2265	11·0285041	39
22	8·9709468	2238	1·0290532	9·9980921	19·8	0·0019079	8·9728547	2258	11·0271453	38
23	8·9722895	2231	1·0277105	9·9980802	19·8	0·0019198	8·9742092	2251	11·0257908	37
24	8·9736280	2224	1·0263720	9·9980683	20·0	0·0019317	8·9755597	2244	11·0244403	36
25	8·9749624	2217	1·0250376	9·9980563	20·0	0·0019437	8·9769060	2237	11·0230940	35
26	8·9762926	2210	1·0237074	9·9980443	20·0	0·0019557	8·9782483	2230	11·0217517	34
27	8·9776188	2203	1·0223812	9·9980323	20·2	0·0019677	8·9795865	2224	11·0204135	33
28	8·9789408	2197	1·0210592	9·9980202	20·2	0·0019798	8·9809206	2217	11·0190794	32
29	8·9802589	2190	1·0197411	9·9980081	20·2	0·0019919	8·9822507	2210	11·0177493	31
30	8·9815729	2184	1·0184271	9·9979960	20·3	0·0020040	8·9835769	2204	11·0164231	30
31	8·9828829	2177	1·0171171	9·9979838	20·3	0·0020162	8·9848991	2197	11·0151009	29
32	8·9841889	2170	1·0158111	9·9979716	20·5	0·0020284	8·9862173	2191	11·0137827	28
33	8·9854910	2163	1·0145090	9·9979593	20·5	0·0020407	8·9875317	2184	11·0124683	27
34	8·9867891	2157	1·0132109	9·9979470	20·5	0·0020530	8·9888421	2178	11·0111579	26
35	8·9880834	2150	1·0119166	9·9979347	20·7	0·0020653	8·9901487	2171	11·0098513	25
36	8·9893737	2144	1·0106263	9·9979223	20·7	0·0020777	8·9914514	2165	11·0085486	24
37	8·9906602	2138	1·0093398	9·9979099	20·7	0·0020901	8·9927503	2159	11·0072497	23
38	8·9919429	2131	1·0080571	9·9978975	20·8	0·0021025	8·9940454	2152	11·0059546	22
39	8·9932217	2125	1·0067783	9·9978850	20·8	0·0021150	8·9953367	2146	11·0046633	21
40	8·9944968	2119	1·0055032	9·9978725	21·0	0·0021275	8·9966243	2140	11·0033757	20
41	8·9957681	2112	1·0042319	9·9978599	21·0	0·0021401	8·9979081	2134	11·0020919	19
42	8·9970356	2106	1·0029644	9·9978473	21·0	0·0021527	8·9991883	2127	11·0008117	18
43	8·9982994	2100	1·0017006	9·9978347	21·2	0·0021653	9·0004647	2121	10·9995353	17
44	8·9995595	2094	1·0004405	9·9978220	21·2	0·0021780	9·0017375	2115	10·9982625	16
45	9·0008160	2088	0·9991840	9·9978093	21·2	0·0021907	9·0030066	2108	10·9969934	15
46	9·0020687	2082	0·9979313	9·9977966	21·3	0·0022034	9·0042721	2103	10·9957279	14
47	9·0033179	2076	0·9966821	9·9977838	21·3	0·0022162	9·0055340	2097	10·9944660	13
48	9·0045634	2070	0·9954366	9·9977710	21·3	0·0022290	9·0067924	2091	10·9932076	12
49	9·0058053	2064	0·9941947	9·9977582	21·5	0·0022418	9·0080471	2085	10·9919529	11
50	9·0070436	2058	0·9929564	9·9977453	21·7	0·0022547	9·0092984	2079	10·9907016	10
51	9·0082784	2052	0·9917216	9·9977323	21·7	0·0022677	9·0105461	2074	10·9894539	9
52	9·0095096	2046	0·9904904	9·9977194	21·7	0·0022806	9·0117903	2068	10·9882097	8
53	9·0107374	2040	0·9892626	9·9977064	21·8	0·0022936	9·0130310	2062	10·9869690	7
54	9·0119616	2034	0·9880384	9·9976933	21·8	0·0023067	9·0142682	2056	10·9857318	6
55	9·0131823	2029	0·9868177	9·9976803	21·8	0·0023197	9·0155021	2051	10·9844979	5
56	9·0143996	2023	0·9856004	9·9976672	22·0	0·0023328	9·0167325	2045	10·9832675	4
57	9·0156135	2017	0·9843865	9·9976540	22·0	0·0023460	9·0179594	2039	10·9820406	3
58	9·0168239	2011	0·9831761	9·9976408	22·0	0·0023592	9·0191831	2034	10·9808169	2
59	9·0180309	2006	0·9819691	9·9976276	22·2	0·0023724	9·0204033	2028	10·9795967	1
60	9·0192346		0·9807654	9·9976143		0·0023857	9·0216202		10·9783798	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp sin.	Cosine	D10″	Comp.cos	Tangent	D10″	Cotangent	′
0	9·0192346	2000	0·9807654	9·9976143	22·0	0·0023857	9·0216202	2023	10·9783798	60
1	9·0204348	1995	0·9795652	9·9976011	22·3	0·0023989	9·0228336	2017	10·9771662	59
2	9·0216318	1989	0·9783682	9·9975877	22·5	0·0024123	9·0240441	2011	10·9759559	58
3	9·0228254	1984	0·9771746	9·9975743	22·5	0·0024257	9·0252510	2006	10·9747490	57
4	9·0240157	1978	0·9759843	9·9975609	22·3	0·0024391	9·0264548	2001	10·9735452	56
5	9·0252027	1973	0·9747973	9·9975473	22·5	0·0024527	9·0276554	1995	10·9723446	55
6	9·0263865	1967	0·9736135	9·9975340	22·5	0·0024660	9·0288524	1990	10·9711476	54
7	9·0275669	1962	0·9724331	9·9975205	22·7	0·0024795	9·0300464	1985	10·9699536	53
8	9·0287442	1957	0·9712558	9·9975069	22·7	0·0024931	9·0312373	1979	10·9687627	52
9	9·0299182	1951	0·9700818	9·9974933	22·7	0·0025067	9·0324249	1974	10·9675751	51
10	9·0310890	1946	0·9689110	9·9974797	22·8	0·0025203	9·0336093	1969	10·9663907	50
11	9·0322567	1941	0·9677433	9·9974660	22·8	0·0025340	9·0347906	1964	10·9652094	49
12	9·0334212	1935	0·9665788	9·9974523	22·8	0·0025477	9·0359688	1958	10·9640312	48
13	9·0345825	1930	0·9654175	9·9974386	23·0	0·0025614	9·0371439	1953	10·9628561	47
14	9·0357407	1925	0·9642593	9·9974248	23·0	0·0025752	9·0383159	1948	10·9616841	46
15	9·0368958	1920	0·9631042	9·9974110	23·2	0·0025890	9·0394848	1943	10·9605152	45
16	9·0380477	1915	0·9619523	9·9973971	23·0	0·0026029	9·0406506	1938	10·9593494	44
17	9·0391966	1910	0·9608034	9·9973833	23·3	0·0026167	9·0418134	1933	10·9581866	43
18	9·0403424	1905	0·9596576	9·9973693	23·2	0·0026307	9·0429731	1928	10·9570269	42
19	9·0414852	1900	0·9585148	9·9973554	23·3	0·0026446	9·0441299	1923	10·9558701	41
20	9·0426249	1895	0·9573751	9·9973414	23·5	0·0026586	9·0452836	1918	10·9547164	40
21	9·0437617	1889	0·9562383	9·9973273	23·5	0·0026727	9·0464343	1913	10·9535657	39
22	9·0448954	1884	0·9551046	9·9973132	23·5	0·0026868	9·0475821	1908	10·9524179	38
23	9·0460261	1879	0·9539739	9·9972991	23·5	0·0027009	9·0487270	1903	10·9512730	37
24	9·0471538	1875	0·9528462	9·9972850	23·7	0·0027150	9·0498689	1898	10·9501311	36
25	9·0482786	1870	0·9517214	9·9972708	23·7	0·0027292	9·0510078	1893	10·9489922	35
26	9·0494005	1865	0·9505995	9·9972566	23·8	0·0027434	9·0521439	1889	10·9478561	34
27	9·0505194	1860	0·9494806	9·9972423	23·8	0·0027577	9·0532771	1884	10·9467229	33
28	9·0516354	1855	0·9483646	9·9972280	23·8	0·0027720	9·0544074	1879	10·9455926	32
29	9·0527485	1850	0·9472515	9·9972137	24·0	0·0027863	9·0555349	1875	10·9444651	31
30	9·0538588	1845	0·9461412	9·9971993	24·0	0·0028007	9·0566595	1870	10·9433405	30
31	9·0549661	1841	0·9450339	9·9971849	24·2	0·0028151	9·0577813	1865	10·9422187	29
32	9·0560706	1836	0·9439294	9·9971704	24·2	0·0028296	9·0589002	1860	10·9410998	28
33	9·0571723	1831	0·9428277	9·9971559	24·2	0·0028441	9·0600164	1855	10·9399836	27
34	9·0582711	1827	0·9417289	9·9971414	24·3	0·0028586	9·0611297	1851	10·9388703	26
35	9·0593672	1822	0·9406328	9·9971268	24·5	0·0028732	9·0622403	1846	10·9377597	25
36	9·0604604	1817	0·9395396	9·9971122	24·3	0·0028878	9·0633482	1842	10·9366518	24
37	9·0615509	1813	0·9384491	9·9970976	24·5	0·0029024	9·0644533	1837	10·9355467	23
38	9·0626386	1808	0·9373614	9·9970829	24·5	0·0029171	9·0655556	1833	10·9344444	22
39	9·0637235	1804	0·9362765	9·9970682	24·5	0·0029318	9·0666553	1828	10·9333447	21
40	9·0648057	1799	0·9351943	9·9970535	24·7	0·0029465	9·0677522	1824	10·9322478	20
41	9·0658852	1794	0·9341148	9·9970387	24·7	0·0029613	9·0688465	1819	10·9311535	19
42	9·0669619	1790	0·9330381	9·9970239	24·8	0·0029761	9·0699381	1815	10·9300619	18
43	9·0680360	1786	0·9319640	9·9970090	24·8	0·0029910	9·0710270	1810	10·9289730	17
44	9·0691074	1781	0·9308926	9·9969941	24·8	0·0030059	9·0721133	1806	10·9278867	16
45	9·0701761	1777	0·9298239	9·9969792	25·0	0·0030208	9·0731969	1802	10·9268031	15
46	9·0712421	1772	0·9287579	9·9969642	25·0	0·0030358	9·0742779	1797	10·9257221	14
47	9·0723055	1768	0·9276945	9·9969492	25·0	0·0030508	9·0753563	1793	10·9246437	13
48	9·0733663	1763	0·9266337	9·9969342	25·2	0·0030658	9·0764321	1789	10·9235679	12
49	9·0744244	1759	0·9255756	9·9969191	25·2	0·0030809	9·0775053	1784	10·9224947	11
50	9·0754799	1755	0·9245201	9·9969040	25·3	0·0030960	9·0785760	1780	10·9214240	10
51	9·0765329	1750	0·9234671	9·9968888	25·3	0·0031112	9·0796441	1776	10·9203559	9
52	9·0775832	1746	0·9224168	9·9968736	25·3	0·0031264	9·0807096	1772	10·9192904	8
53	9·0786310	1742	0·9213690	9·9968584	25·5	0·0031416	9·0817726	1767	10·9182274	7
54	9·0796762	1738	0·9203238	9·9968431	25·5	0·0031569	9·0828331	1763	10·9171669	6
55	9·0807189	1733	0·9192811	9·9968278	25·5	0·0031722	9·0838911	1759	10·9161089	5
56	9·0817590	1729	0·9182410	9·9968125	25·7	0·0031875	9·0849466	1755	10·9150534	4
57	9·0827966	1725	0·9172034	9·9967971	25·7	0·0032029	9·0859996	1751	10·9140004	3
58	9·0838317	1721	0·9161683	9·9967817	25·8	0·0032183	9·0870501	1747	10·9129499	2
59	9·0848643	1717	0·9151357	9·9967662	25·8	0·0032338	9·0880981	1743	10·9119019	1
60	9·0858945		0·9141055	9·9967507		0·0032493	9·0891438		10·9108562	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

7 Deg.

′	Sine	D10″	Comp.sin	Cosine	D10″	Comp.cos	Tangent	D10″	Cotangent	′
0	9·0858945	1713	0·9141055	9·9967507	25·8	0·0032493	9·0891438	1739	10·9108562	60
1	9·0869221	1709	0·9130779	9·9967352	26·0	0·0032648	9·0901869	1735	10·9098131	59
2	9·0879473	1704	0·9120527	9·9967196	26·0	0·0032804	9·0912[illegible]	1731	10·9087723	58
3	9·0889700	1700	0·9110300	9·9967040	26·0	0·0032960	9·0922660	1727	10·9077340	57
4	9·0899903	1696	0·9100097	9·9966884	26·2	0·0033116	9·0933020	1723	10·9066980	56
5	9·0910082	1692	0·9089918	9·9966727	26·2	0·0033273	9·0943355	1719	10·9056645	55
6	9·0920237	1688	0·9079763	9·9966570	26·3	0·0033430	9·0953667	1715	10·9046333	54
7	9·0930367	1684	0·9069633	9·9966412	26·3	0·0033588	9·0963955	1711	10·9036045	53
8	9·0940474	1680	0·9059526	9·9966254	26·3	0·0033746	9·0974219	1707	10·9025781	52
9	9·0950556	1676	0·9049444	9·9966096	26·5	0·0033904	9·0984460	1703	10·9015540	51
10	9·0960615	1673	0·9039385	9·9965937	26·5	0·0034063	9·0994678	1699	10·9005322	50
11	9·0970651	1669	0·9029349	9·9965778	26·5	0·0034222	9·1004872	1695	10·8995128	49
12	9·0980662	1665	0·9019338	9·9965619	26·7	0·0034381	9·1015044	1691	10·8984956	48
13	9·0990651	1661	0·9009349	9·9965459	26·7	0·0034541	9·1025192	1687	10·8974808	47
14	9·1000616	1657	0·8999384	9·9965299	26·8	0·0034701	9·1035317	1684	10·8964683	46
15	9·1010558	1653	0·8989442	9·9965138	26·8	0·0034862	9·1045420	1680	10·8954580	45
16	9·1020477	1649	0·8979523	9·9964977	26·8	0·0035023	9·1055500	1676	10·8944500	44
17	9·1030373	1645	0·8969627	9·9964816	26·8	0·0035184	9·1065557	1672	10·8934443	43
18	9·1040246	1642	0·8959754	9·9964655	27·0	0·0035345	9·1075591	1669	10·8924409	42
19	9·1050096	1638	0·8949904	9·9964493	27·2	0·0035507	9·1085604	1665	10·8[illegible]	41
20	9·1059924	1634	0·8940076	9·9964330	27·2	0·0035670	9·1095594	1661	10·[illegible]	40
21	9·1069729	1630	0·8930271	9·9964167	27·2	0·0035833	9·1105562	1658	10·889[illegible]	39
22	9·1079512	1627	0·8920488	9·9964004	27·2	0·0035996	9·1115508	1654	10·8884492	38
23	9·1089272	1623	0·8910728	9·9963841	27·3	0·0036159	9·1125431	1650	10·8874569	37
24	9·1099010	1619	0·8900990	9·9963677	27·3	0·0036323	9·1135333	1647	10·8864667	36
25	9·1108726	1616	0·8891274	9·9963513	27·5	0·0036487	9·1145213	1643	10·8854787	35
26	9·1118420	1612	0·8881580	9·9963348	27·5	0·0036652	9·1155072	1639	10·8844928	34
27	9·1128092	1608	0·8871908	9·9963183	27·5	0·0036817	9·1164909	1636	10·8835091	33
28	9·1137742	1605	0·8862258	9·9963018	27·7	0·0036982	9·1174724	1632	10·8825276	32
29	9·1147370	1601	0·8852630	9·9962852	27·7	0·0037148	9·1184518	1629	10·8815482	31
30	9·1156977	1597	0·8843023	9·9962686	27·8	0·0037314	9·1194291	1625	10·8805709	30
31	9·1166562	1594	0·8833438	9·9962519	27·8	0·0037481	9·1204043	1622	10·8795957	29
32	9·1176125	1590	0·8823875	9·9962352	27·8	0·0037648	9·1213773	1618	10·8786227	28
33	9·1185667	1587	0·8814333	9·9962185	28·0	0·0037815	9·1223482	1615	10·8776518	27
34	9·1195188	1583	0·8804812	9·9962017	28·0	0·0037983	9·1233171	1611	10·8766829	26
35	9·1204688	1580	0·8795312	9·9961849	28·0	0·0038151	9·1242839	1608	10·8757161	25
36	9·1214167	1576	0·8785833	9·9961681	28·2	0·0038319	9·1252486	1604	10·8747514	24
37	9·1223624	1573	0·8776376	9·9961512	28·2	0·0038488	9·1262112	1601	10·8737888	23
38	9·1233061	1569	0·8766939	9·9961343	28·2	0·0038657	9·1271718	1597	10·8728282	22
39	9·1242477	1566	0·8757523	9·9961174	28·3	0·0038826	9·1281303	1594	10·8718697	21
40	9·1251872	1562	0·8748128	9·9961004	28·3	0·0038996	9·1290868	1591	10·8709132	20
41	9·1261246	1559	0·8738754	9·9960834	28·5	0·0039166	9·1300413	1587	10·8699587	19
42	9·1270600	1556	0·8729400	9·9960663	28·5	0·0039337	9·1309937	1584	10·8690063	18
43	9·1279934	1552	0·8720066	9·9960492	28·5	0·0039508	9·1319442	1581	10·8680558	17
44	9·1289247	1549	0·8710753	9·9960321	28·7	0·0039679	9·1328926	1577	10·8671074	16
45	9·[illegible]8539	1545	0·8701461	9·9960149	28·7	0·0039851	9·1338391	[illegible]	10·8661609	15
46	9·1307812	1542	0·8692188	9·9959977	28·8	0·0040023	9·1347835	[illegible]	10·8652165	14
47	9·1317064	1539	0·8682936	9·9959804	28·8	0·0040196	9·1357260	1567	10·8642740	13
48	9·1326297	1535	0·8673703	9·9959631	28·8	0·0040369	9·1366665	1564	10·8633335	12
49	9·1335509	1532	0·8664491	9·9959458	29·0	0·0040542	9·1376051	1561	10·8623949	11
50	9·1344702	1529	0·8655298	9·9959284	29·0	0·0040716	9·1385417	1558	10·8614583	10
51	9·1353875	1525	0·8646125	9·9959111	29·2	0·0040889	9·1394764	1555	10·8605236	9
52	9·1363028	1522	0·8636972	9·9958936	29·2	0·0041064	9·1404092	1551	10·8595908	8
53	9·1372161	1519	0·8627839	9·9958761	29·2	0·0041239	9·1413400	1548	10·8586600	7
54	9·1381275	1516	0·8618725	9·9958586	29·2	0·0041414	9·1422689	1545	10·8577311	6
55	9·1390370	1513	0·8609630	9·9958411	29·3	0·0041589	9·1431959	1542	10·8568041	5
56	9·1399445	1509	0·8600555	9·9958235	29·3	0·0041765	9·1441210	1539	10·8558790	4
57	9·1408501	1506	0·8591499	9·9958059	29·5	0·0041941	9·1450442	1536	10·8549558	3
58	9·1417537	1503	0·8582463	9·9957882	29·5	0·0042118	9·1459655	1532	10·8540345	2
59	9·1426555	1500	0·8573445	9·9957705	29·5	0·0042295	9·1468849	1529	10·8531151	1
60	9·1435553		0·8564447	9·9957528		0·0042472	9·1478025		10·8521975	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin	Cotang.	D10″	Tangent	′

′	Sine.	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·1435553	1496	0·8564447	9·9957528	29·7	0·0042472	9·1478025	1526	10·8521975	60
1	9·1444532	1493	0·8555468	9·9957350	29·7	0·0042650	9·1487182	1523	10·8512818	59
2	9·1453493	1490	0·8546507	9·9957172	29·8	0·0042828	9·1496321	1520	10·8503679	58
3	9·1462435	1487	0·8537565	9·9956993	29·8	0·0043007	9·1505441	1517	10·8494559	57
4	9·1471358	1484	0·8528642	9·6956815	30·0	0·0943185	9·1514543	1514	10·8485457	56
5	9·1480262	1481	0·8519738	9·9956635	30·0	0·0043365	9·1523627	1511	10·8476373	55
6	9·1489148	1478	0·8510852	9·9956456	80·0	0·0043544	9·1532692	1508	10·8467308	54
7	9·1498015	1475	0·8501985	9·9956276	30·2	0·0043724	9·1541739	1505	10·8458261	53
8	9·1506864	1472	0·8493136	9·9956095	30·2	0·0043905	9·1550769	1502	10·8449231	52
9	9·1515694	1469	0·8484306	9·9955915	30·2	0·0044085	9·1559780	1499	10·8440220	51
10	9·1524507	1466	0·8475493	9·9955734	30·3	0·0044266	9·1568773	1496	10·8431227	50
11	9·1533301	1463	0·8466699	9·9955552	30·3	0·0044448	9·1577748	1493	10·8422252	49
12	9·1542076	1460	0·8457924	9·9955370	30·3	0·0044630	9·1586706	1490	10·8413294	48
13	9·1550834	1457	0·8449166	9·9955188	30·5	0·0044812	9·1595646	1487	10·8404354	47
14	9·1559574	1454	0·8440426	9·9955005	30·5	0·0044995	9·1604569	1484	10·8395431	46
15	9·1568296	1451	0·8431704	9·9954822	30·5	0·0045178	9·1613473	1481	10·8386527	45
16	9·1577000	1448	0·8423000	9·9954639	30·7	0·0045361	9·1622361	1478	10·8377639	44
17	9·1585686	1445	0·8414314	9·9954455	30·7	0·0045545	9·1631231	1475	10·8368769	43
18	9·1594354	1442	0·8405646	9·9954271	30·7	0·0045729	9·1640083	1473	10·8359917	42
19	9·1603005	1439	0·8396995	9·9954087	30·8	0·0045913	9·1648919	1470	10·8351081	41
20	9·1611639	1436	0·8388361	9·9953902	30·8	0·0046098	9·1657737	1467	10·8342263	40
21	9·1620254	1433	0·8379746	9·9953717	31·0	0·0046283	9·1666538	1464	10·8333462	39
22	9·1628853	1430	0·8371147	9·9953531	31·0	0·0046469	9·1675322	1461	10·8324678	38
23	9·1637434	1427	0·8362566	9·9953345	31·0	0·0046655	9·1684089	1458	10·8315911	37
24	9·1645998	1424	0·8354002	9·9953159	31·2	0·0046841	9·1692839	1455	10·8307161	36
25	9·1654544	1422	0·8345456	9·9952972	31·2	0·0047028	9·1701572	1453	10·8298428	35
26	9.1663074	1419	0·8336926	9·9952785	31·3	0·0047215	9·1710289	1450	10·8289711	34
27	9·1671586	1416	0·8328414	9·9952597	31·3	0·0047403	9·1718989	1447	10·8281011	33
28	9·1680081	1413	0·8319919	9·9952409	31·3	0·0047591	9·1727672	1444	10·8272328	32
29	9·1688559	1410	0·8311441	9·9952221	31·3	0·0047779	9·1736338	1442	10·8263662	31
30	9·1697021	1407	0·8302979	9·9952033	31·5	0·0047967	9·1744988	1439	10·8255012	30
31	9·1705465	1405	0·8294535	9·9951844	31·7	0·0048156	9·1753622	1436	10·8246378	29
32	9·1713893	1402	0·8286107	9·9951654	31·7	0·0048346	9·1762239	1433	10·8237761	28
33	9·1722305	1399	0·8277695	9·9951464	31·7	0·0048536	9·1770840	1431	10·8229160	27
34	9·1730699	1396	0·8269301	9·9951274	31·7	0·0048726	9·1779425	1428	10·8220575	26
35	9·1739077	1394	0·8260923	9·9951084	31·8	0·0048916	9·1787993	1425	10·8212007	25
36	9·1747439	1391	0·8252561	9·9950893	31·8	0·0049107	9·1796546	1423	10·8203454	24
37	9·1755784	1388	0·8244216	9·9950702	32·0	0·0049298	9·1805082	1420	10·8194918	23
38	9·1764112	1385	0·8235888	9·9950510	32·0	0·0049490	9·1813602	1417	10·8186398	22
39	9·1772425	1383	0·8227575	9·9950318	32·0	0·0049682	9·1822106	1415	10·8177894	21
40	9·1780721	1380	0·8219279	9·9950126	32·2	0·0049874	9·1830595	1412	10·8169405	20
41	9·1789001	1377	0·8210999	9·9949933	32·2	0·0050067	9·1839068	1409	10·8160932	19
42	9·1797265	1374	0·8202735	9·9949740	32·3	0·0050260	9·1847525	1407	10·8152475	18
43	9·1805512	1372	0·8194488	9·9949546	32·3	0·0050454	9·1855966	1404	10·8144034	17
44	9·1813744	1369	0·8186256	9·9949352	32·3	0·0050648	9·1864392	1402	10·8135608	16
45	9·1821960	1367	0·8178040	9·9949158	32·3	0·0050842	9·1872802	1399	10·8127198	15
46	9·1830160	1364	0·8169840	9·9948964	32·5	0·0051036	9·1881196	1396	10·8118804	14
47	9·1838344	1361	0·8161656	9·9948769	32·7	0·0051231	9·1889575	1394	10·8110425	13
48	9·1846512	1359	0·8153488	9·9948573	32·7	0·0051427	9·1897939	1391	10·8102061	12
49	9·1854665	1356	0·8145335	9·9948377	32·7	0·0051623	9·1906287	1389	10·8093713	11
50	9·1862802	1353	0·8137198	9·9948181	32·7	0·0051819	9·1914621	1386	10·8085379	10
51	9·1870923	1351	0·8129077	9·9947985	32·8	0·0052015	9·1922939	1384	10·8077061	9
52	9·1879029	1348	0·8120971	9·9947788	32·8	0·0052212	9·1931241	1381	10·8068759	8
53	9·1887120	1346	0·8112880	9·9947591	33·0	0·0052409	9·1939529	1379	10·8060471	7
54	9·1895195	1343	0·8104805	9·9947393	33·0	0·0052607	9·1947802	1376	10·8052198	6
55	9·1903254	1341	0·8096746	9·9947195	33·0	0·0052805	9·1956059	1374	10·8043941	5
56	9·1911299	1338	0·8088701	9·9946997	33·2	0·0053003	9·1964302	1371	10·8035698	4
57	9·1919328	1336	0·8080672	9·9946798	33·2	0·0053202	9·1972530	1369	10·8027470	3
58	9·1927342	1333	0·8072658	9·9946599	33·3	0·0053401	9·1980743	1366	10·8019257	2
59	9·1935341	1330	0·8064659	9·9946399	33·3	0·0053601	9·1988941	1364	10·8011059	1
60	9·1943324		0·8056676	9·9946199		0·0053801	9·1997125		10·8002875	0
′	Cosine.	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

9 Deg. Tab. 18.

′	Sine	D10″	Comp sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·1943324	1328	0·8056676	9·9946199	33·3	0·0053801	9·1997125	1361	10·8002875	60
1	9·1951293	1326	0·8048707	9·9945999	33·5	0·0054001	9·2005294	1359	10·7994706	59
2	9·1959247	1323	0·8040753	9·9945798	33·5	0·0054202	9·2013449	1356	10·7986551	58
3	9·1967186	1321	0·8032814	9·9945597	33·5	0·0054403	9·2021588	1354	10·7978412	57
4	9·1975110	1318	0·8024890	9·9945396	33·7	0·0054604	9·2029714	1352	10·7970286	56
5	9·1983019	1316	0·8016981	9·9945194	33·7	0·0054806	9·2037825	1349	10·7962175	55
6	9·1990913	1313	0·8009087	9·9944992	33·8	0·0055008	9·2045922	1347	10·7954078	54
7	9·1998793	1311	0·8001207	9·9944789	33·8	0·0055211	9·2054004	1345	10·7945996	53
8	9·2006658	1308	0·7993342	9·9944587	34·0	0·0055413	9·2062072	1342	10·7937928	52
9	9·2014509	1306	0·7985491	9·9944383	34·0	0·0055617	9·2070126	1340	10·7929874	51
10	9·2022345	1304	0·7977655	9·9944180	34·0	0·0055820	9·2078165	1338	10·7921835	50
11	9·2030167	1301	0·7969833	9·9943975	34·2	0·0056025	9·2086191	1335	10·7913809	49
12	9·2037974	1299	0·7962026	9·9943771	34·2	0·0056229	9·2094203	1333	10·7905797	48
13	9·2045766	1296	0·7954234	9·9943566	34·2	0·0056434	9·2102200	1331	10·7897800	47
14	9·2053545	1294	0·7946455	9·9943361	34·2	0·0056639	9·2110184	1328	10·7889816	46
15	9·2061309	1292	0·7938691	9·9943156	34·3	0·0056844	9·2118153	1326	10·7881847	45
16	9·2069059	1289	0·7930941	9·9942950	34·3	0·0057050	9·2126109	1324	10·7873891	44
17	9·2076795	1287	0·7923205	9·9942743	34·5	0·0057257	9·2134051	1321	10·7865949	43
18	9·2084516	1285	0·7915484	9·9942537	34·5	0·0057463	9·2141980	1319	10·7858020	42
19	9·2092224	1282	0·7907776	9·9942330	34·7	0·0057670	9·2149894	1317	10·7850106	41
20	9·2099917	1280	0·7900083	9·9942122	34·7	0·0057878	9·2157795	1315	10·7842205	40
21	9·2107597	1278	0·7892403	9·9941914	34·7	0·0058086	9·2165683	1312	10·7834317	39
22	9·2115263	1275	0·7884737	9·9941706	34·8	0·0058294	9·2173556	1310	10·7826444	38
23	9·2122914	1273	0·7877086	9·9941498	34·8	0·0058502	9·2181417	1308	10·7818583	37
24	9·2130552	1271	0·7869448	9·9941289	35·0	0·0058711	9·2189264	1305	10·7810736	36
25	9·2138176	1268	0·7861824	9·9941079	35·0	0·0058921	9·2197097	1303	10·7802903	35
26	9·2145787	1266	0·7854213	9·9940870	35·0	0·0059130	6·2204917	1301	10·7795083	34
27	9·2153384	1264	0·7846616	9·9940659	35·2	0·0059341	9·2212724	1299	10·7787276	33
28	9·2160967	1261	0·7839033	9·9940449	35·2	0·0059551	9·2220518	1297	10·7779482	32
29	9·2168536	1259	0·7831464	9·9940238	35·2	0·0059762	9·2228298	1291	10·7771702	31
30	9·2176092	1257	0·7823908	9·9940027	35·3	0·0059973	9·2236065	1292	10·7763935	30
31	9·2183635	1255	0·7816365	9·9939815	35·3	0·0060185	9·2243819	1290	10·7756181	29
32	9·2191164	1253	0·7808836	9·9939603	35·3	0·0060397	9·2251561	1288	10·7748439	28
33	9·2198680	1250	0·7801320	9·9939391	35·5	0·0060609	9·2259289	1286	10·7740711	27
34	9·2206182	1248	0·7793818	9·9939178	35·5	0·0060822	9·2267004	1284	10·7732996	26
35	9·2213671	1246	0·7786329	9·9938965	35·5	0·0061035	9·2274706	1281	10·7725294	25
36	9·2221147	1244	0·7778853	9·9938752	35·7	0·0061248	9·2282395	1279	10·7717605	24
37	9·2228609	1242	0·7771391	9·9938538	35·7	0·0061462	9·2290071	1277	10·7709929	23
38	9·2236059	1239	0·7763941	9·9938324	35·7	0·0061676	9·2297735	1275	10·7702265	22
39	9·2243495	1237	0·7756505	9·9938109	35·8	0·0061891	9·2305386	1273	10·7694614	21
40	9·2250918	1235	0·7749082	9·9937894	35·8	0·0062106	9·2313024	1271	10·7686976	20
41	9·2258328	1233	0·7741672	9·9937679	36·0	0·0062321	9·2320650	1269	10·7679350	19
42	9·2265725	1231	0·7734275	9·9937463	36·0	0·0062537	9·2328262	1267	10·7671738	18
43	9·2273110	1228	0·7726890	9·9937247	36·2	0·0062753	9·2335863	1265	10·7664137	17
44	9·2280481	1226	0·7719519	9·9937030	36·2	0·0062970	9·2343451	1262	10·7656549	16
45	9·2287839	1224	0·7712161	9·9936813	36·2	0·0063187	9·2351026	1260	10·7648974	15
46	9·2295185	1222	0·7704815	9·9936596	36·3	0·0063404	9·2358589	1258	10·7641411	14
47	9·2302518	1220	0·7697482	9·9936378	36·3	0·0063622	9·2366139	1256	10·7633861	13
48	9·2309838	1218	0·7690162	9·9936160	36·3	0·0063840	9·2373678	1254	10·7626322	12
49	9·2317145	1216	0·7682855	9·9935942	36·5	0·0064058	9·2381203	1252	10·7618797	11
50	9·2324440	1214	0·7675560	9·9935723	36·5	0·0064277	9·2388717	1250	10·7611283	10
51	9·2331722	1212	0·7668278	9·9935504	36·5	0·0064496	9·2396218	1248	10·7603782	9
52	9·2338992	1209	0·7661008	9·9935285	36·7	0·0064715	9·2403708	1246	10·7596292	8
53	9·2346249	1207	0·7653751	9·9935065	36·7	0·0064935	9·2411185	1244	10·7588815	7
54	9·2353494	1205	0·7646506	9·9934844	36·8	0·0065156	9·2418650	1242	10·7581350	6
55	9·2360726	1203	0·7639274	9·9934624	36·8	0·0065376	9·2426103	1240	10·7573897	5
56	9·2367946	1201	0·7632054	9·9934403	37·0	0·0065597	9·2433543	1238	10·7560457	4
57	9·2375153	1199	0·7624847	9·9934181	37·0	0·0065819	9·2440972	1236	10·7559028	3
58	9·2382349	1197	0·7617651	9·9933959	37·0	0·0066041	9·2448389	1234	10·7551611	2
59	9·2389532	1195	0·7610468	9·9933737	37·0	0·0066263	9·2455794	1232	10·7544206	1
60	9·2396702		0·7603298	9·9933515		0·0066485	9·2463188		10·7536812	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp. sin	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent.	′
0	9·2396702	1193	0·7603298	9·9933515	37·2	0·0066485	9·2463188	1230	10·7536812	60
1	9·2403861	1191	0·7596139	9·9933292	37·2	0·0066708	9·2470569	1228	10·7529431	59
2	9·2411007	1189	0·7588993	9·9933068	37·3	0·0066932	9·2477939	1226	10·7522061	58
3	9·2418141	1187	0·7581859	9·9932845	37·3	0·0067155	9·2485297	1224	10·7514703	57
4	9·2425264	1185	0·7574736	9·9932621	37·5	0·0067379	9·2492643	1222	10·7507357	56
5	9·2432374	1183	0·7567626	9·9932396	37·5	0·0067604	9·2499978	1220	10·7500022	55
6	9·2439472	1181	0·7560528	9·9932171	37·5	0·0067829	9·2507301	1218	10·7492699	54
7	9·2446558	1179	0·7553442	9·9931946	37·7	0·0068054	9·2514612	1216	10·7485388	53
8	9·2453632	1177	0·7546368	9·9931720	37·7	0·0068280	9·2521912	1215	10·7478088	52
9	9·2460695	1175	0·7539305	9·9931494	37·7	0·0068506	9·2529200	1213	10·7470800	51
10	9·2467746	1173	0·7532254	9·9931268	37·8	0·0068732	9·2536477	1211	10·7463523	50
11	9·2474784	1171	0·7525216	9·9931041	37·8	0·0068959	9·2543743	1209	10·7456257	49
12	9·2481811	1169	0·7518189	9·9930814	37·8	0·0069186	9·2550997	1207	10·7449003	48
13	9·2488827	1167	0·7511173	9·9930587	38·0	0·0069413	9·2558240	1205	10·7441760	47
14	9·2495830	1165	0·7504170	9·9930359	38·0	0·0069641	9·2565472	1203	10·7434528	46
15	9·2502822	1163	0·7497178	9·9930131	38·2	0·0069869	9·2572692	1201	10·7427308	45
16	9·2509803	1161	0·7490197	9·9929902	38·2	0·0070098	9·2579901	1200	10·7420099	44
17	9·2516772	1159	0·7483228	9·9929673	38·2	0·0070327	9·2587099	1198	10·7412901	43
18	9·2523729	1158	0·7476271	9·9929444	38·3	0·0070556	9·2594285	1196	10·7405715	42
19	9·2530675	1156	0·7469325	9·9929214	38·3	0·0070786	9·2601461	1194	10·7398539	41
20	9·2537609	1154	0·7462391	9·9928984	38·5	0·0071016	9·2608625	1192	10·7391375	40
21	9·2544532	1152	0·7455468	9·9928753	38·5	0·0071247	9·2615779	1190	10·7384221	39
22	9·2551444	1150	0·7448556	9·9928522	38·5	0·0071478	9·2622921	1188	10·7377079	38
23	9·2558344	1148	0·7441656	9·9928291	38·7	0·0071709	9·2630053	1186	10·7369947	37
24	9·2565233	1146	0·7434767	9·9928059	38·7	0·0071941	9·2637173	1185	10·7362827	36
25	9·2572110	1144	0·7427890	9·9927827	38·7	0·0072173	9·2644283	1183	10·7355717	35
26	9·2578977	1142	0·7421023	9·9927595	38·8	0·0072405	9·2651382	1181	10·7348618	34
27	9·2585832	1140	0·7414168	9·9927362	38·8	0·0072638	9·2658470	1179	10·7341530	33
28	9·2592676	1138	0·7407324	9·9927129	39·0	0·0072871	9·2665547	1178	10·7334453	32
29	9·2599509	1137	0·7400491	9·9926895	39·0	0·0073105	9·2672613	1176	10·7327387	31
30	9·2606330	1135	0·7393670	9·9926661	39·0	0·0073339	9·2679669	1174	10·7320331	30
31	9·2613141	1133	0·7386859	9·9926427	39·2	0·0073573	9·2686714	1172	10·7313286	29
32	9·2619941	1131	0·7380059	9·9926192	39·2	0·0073808	9·2693749	1170	10·7306251	28
33	9·2626729	1129	0·7373271	9·9925957	39·2	0·0074043	9·2700772	1169	10·7299228	27
34	9·2633507	1128	0·7366493	9·9925722	39·3	0·0074278	9·2707786	1167	10·7292214	26
35	9·2640274	1126	0·7359726	9·9925486	39·3	0·0074514	9·2714788	1165	10·7285212	25
36	9·2647030	1124	0·7352970	9·9925250	39·5	0·0074750	9·2721780	1164	10·7278220	24
37	9·2653775	1122	0·7346225	9·9925013	39·5	0·0074987	9·2728762	1162	10·7271238	23
38	9·2660509	1120	0·7339491	9·9924776	39·5	0·0075224	9·2735733	1160	10·7264267	22
39	9·2667232	1119	0·7332768	9·9924539	39·7	0·0075461	9·2742694	1158	10·7257306	21
40	9·2673945	1117	0·7326055	9·9924301	39·7	0·0075699	9·2749644	1156	10·7250356	20
41	9·2680647	1115	0·7319353	9·9924063	39·8	0·0075937	9·2756584	1155	10·7243416	19
42	9·2687338	1113	0·7312662	9·9923824	39·8	0·0076176	9·2763514	1153	10·7236486	18
43	9·2694019	1112	0·7305981	9·9923585	39·8	0·0076415	9·2770434	1151	10·7229566	17
44	9·2700689	1110	0·7299311	9·9923346	40·0	0·0076654	9·2777343	1150	10·7222657	16
45	9·2707348	1108	0·7292652	9·9923106	40·0	0·0076894	9·2784242	1148	10·7215758	15
46	9·2713997	1106	0·7286003	9·9922866	40·0	0·0077134	9·2791131	1146	10·7208869	14
47	9·2720635	1105	0·7279365	9·9922626	40·2	0·0077374	9·2798009	1145	10·7201991	13
48	9·2727263	1103	0·7272737	9·9922385	40·2	0·0077615	9·2804878	1143	10·7195122	12
49	9·2733880	1101	0·7266120	9·9922144	40·3	0·0077856	9·2811736	1141	10·7188264	11
50	9·2740487	1100	0·7259513	9·9921902	40·3	0·0078098	9·2818585	1140	10·7181415	10
51	9·2747083	1098	0·7252917	9·9921660	40·3	0·0078340	9·2825423	1138	10·7174577	9
52	9·2753669	1096	0·7246331	9·9921418	40·5	0·0078582	9·2832251	1136	10·7167749	8
53	9·2760245	1094	0·7239755	9·9921175	40·5	0·0078825	9·2839070	1135	10·7160930	7
54	9·2766811	1092	0·7233189	9·9920932	40·5	0·0079068	9·2845878	1133	10·7154122	6
55	9·2773366	1090	0·7226634	9·9920689	40·7	0·0079311	9·2852677	1131	10·7147323	5
56	9·2779911	1089	0·7220089	9·9920445	40·7	0·0079555	9·2859466	1130	10·7140534	4
57	9·2786445	1087	0·7213555	9·9920201	40·8	0·0079799	9·2866245	1128	10·7133755	3
58	9·2792970	1086	0·7207030	9·9919956	40·8	0·0080044	9·2873014	1126	10·7126986	2
59	9·2799484	1084	0·7200516	9·9919711	40·8	0·0080289	9·2879773	1125	10·7120227	1
60	9·2805988		0·7194012	9·9919466		0·0080534	9·2886523		10·7113477	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent.	′

11 Deg. | Tab. 18.

′	Sine	D10″	Comp. sin	Cosine.	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·2805988	1092	0·7194012	9·9919466	41	0·0080534	9·2886523	1123	10·7113477	60
1	9·2812483	1081	0·7187517	9·9919220	41	0·0080780	9·2893263	1122	10·7106737	59
2	9·2818967	1079	0·7181033	9·9918974	41	0·0081026	9·2899993	1120	10·7100007	58
3	9·2825440	1077	0·7174560	9·9918727	41	0·0081273	9·2906713	1118	10·7093287	57
4	9·2831905	1076	0·7168095	9·9918480	41	0·0081520	9·2913424	1117	10·7086576	56
5	9·2838359	1074	0·7161641	9·9918233	41	0·0081767	9·2920126	1116	10·7079874	55
6	9·2844803	1072	0·7155197	9·9917986	41	0·0082014	9·2926817	1114	10·7073183	54
7	9·2851237	1071	0·7148763	9·9917737	41	0·0082263	9·2933500	1112	10·7066500	53
8	9·2857661	1069	0·7142339	9·9917489	41	0·0082511	9·2940172	1111	10·7059828	52
9	9·2864076	1067	0·7135924	9·9917240	41	0·0082760	9·2946836	1109	10·7053164	51
10	9·2870480	1066	0·7129520	9·9916991	42	0·0083009	9·2953489	1107	10·7046511	50
11	9·2876875	1064	0·7123125	9·9916741	42	0·0083259	9·2960134	1106	10·7039866	49
12	9·2883260	1063	0·7116740	9·9916492	42	0·0083508	9·2966769	1104	10·7033231	48
13	9·2889636	1061	0·7110364	9·9916241	42	0·0083759	9·2973395	1103	10·7026605	47
14	9·2896001	1059	0·7103999	9·9915990	42	0·0084010	9·2980011	1101	10·7019989	46
15	9·2902357	1057	0·7097643	9·9915739	42	0·0084261	9·2986618	1100	10·7013382	45
16	9·2908704	1056	0·7091296	9·9915488	42	0·0084512	9·2993216	1098	10·7006784	44
17	9·2915040	1054	0·7084960	9·9915236	42	0·0084764	9·2999804	1097	10·7000196	43
18	9·2921367	1053	0·7078633	9·9914984	42	0·0085016	9·3006383	1095	10·6993617	42
19	9·2927685	1051	0·7072315	9·9914731	42	0·0085269	9·3012954	1094	10·6987046	41
20	9·2933993	1050	0·7066007	9·9914478	42	0·0085522	9·3019514	1092	10·6980486	40
21	9·2940291	1048	0·7059709	9·9914225	42	0·0085775	9·3026066	1090	10·6973934	39
22	9·2946580	1046	0·7053420	9·9913971	42	0·0086029	9·3032609	1089	10·6967391	38
23	9·2952859	1045	0·7047141	9·9913717	42	0·0086283	9·3039143	1087	10·6960857	37
24	9·2959129	1043	0·7040871	9·9913462	42	0·0086538	9·3045667	1086	10·6954333	36
25	9·2965390	1042	0·7034610	9·9913207	42	0·0086793	9·3052183	1084	10·6947817	35
26	9·2971641	1040	0·7028359	9·9912952	43	0·0087048	9·3058689	1083	10·6941311	34
27	9·2977883	1039	0·7022117	9·9912696	43	0·0087304	9·3065187	1081	10·6934813	33
28	9·2984116	1037	0·7015884	9·9912440	43	0·0087560	9·3071675	1080	10·6928325	32
29	9·2990339	1036	0·7009661	9·9912184	43	0·0087816	9·3078155	1078	10·6921845	31
30	9·2996553	1034	0·7003447	9·9911927	43	0·0088073	9·3084626	1077	10·6915374	30
31	9·3002758	1032	0·6997242	9·9911670	43	0·0088330	9·3091088	1075	10·6908912	29
32	9·3008953	1031	0·6991047	9·9911412	43	0·0088588	9·3097541	1074	10·6902459	28
33	9·3015140	1030	0·6984860	9·9911154	43	0·0088846	9·3103985	1072	10·6896015	27
34	9·3021317	1028	0·6978683	9·9910896	43	0·0089104	9·3110421	1071	10·6889579	26
35	9·3027485	1026	0·6972515	9·9910637	43	0·0089363	9·3116848	1070	10·6883152	25
36	9·3033644	1025	0·6966356	9·9910378	43	0·0089622	9·3123266	1068	10·6876734	24
37	9·3039794	1023	0·6960206	9·9910119	43	0·0089881	9·3129675	1067	10·6870325	23
38	9·3045934	1092	0·6954066	9·9909859	43	0·0090141	9·3136076	1065	10·6863924	22
39	9·3052066	1020	0·6947934	9·9909598	43	0·0090402	9·3142468	1064	10·6857532	21
40	9·3058189	1019	0·6941811	9·9909338	43	0·0090662	9·3148851	1062	10·6851149	20
41	9·3064303	1017	0·6935697	9·9909077	44	0·0090923	9·3155226	1061	10·6844774	19
42	9·3070407	1016	0·6929593	9·9908815	44	0·0091185	9·3161592	1060	10·6838408	18
43	9·3076503	1014	0·6923497	9·9908553	44	0·0091447	9·3167950	1058	10·6832050	17
44	9·3082590	1013	0·6917410	9·9908291	44	0·0091709	9·3174299	1057	10·6825701	16
45	9·3088668	1011	0·6911332	9·9908029	44	0·0091971	9·3180640	1055	10·6819360	15
46	9·3094737	1010	0·6905263	9·9907766	44	0·0092234	9·3186972	1054	10·6813028	14
47	9·3100798	1008	0·6899202	9·9907502	44	0·0092498	9·3193295	1053	10·6806705	13
48	9·3106849	1007	0·6893151	9·9907239	44	0·0092761	9·3199611	1051	10·6800389	12
49	9·3112892	1006	0·6887108	9·9906974	44	0·0093026	9·3205918	1050	10·6794082	11
50	9·3118926	1004	0·6881074	9·9906710	44	0·0093290	9·3212216	1048	10·6787784	10
51	9·3124951	1003	0·6875049	9·9906445	44	0·0093555	9·3218506	1047	10·6781494	9
52	9·3130968	1001	0·6869032	9·9906180	44	0·0093820	9·3224788	1045	10·6775212	8
53	9·3136976	1000	0·6863024	9·9905914	44	0·0094086	9·3231061	1044	10·6768939	7
54	9·3142975	998	0·6857025	9·9905648	44	0·0094352	9·3237326	1943	10·6762673	6
55	9·3148965	997	0·6851035	9·9905382	44	0·0094618	9·3243584	1941	10·6756416	5
56	9·3154947	996	0·6845053	9·9905115	44	0·0094885	9·3249832	1940	10·6750168	4
57	9·3160921	994	0·6839079	9·9904848	45	0·0095152	9·3256073	1939	10·6743927	3
58	9·3166885	992	0·6833115	9·9904580	45	0·0095420	9·3262305	1937	10·6739765	2
59	9·3172841	991	0·6827159	9·9904312	45	0·0095688	9·3268529	1936	10·6731471	1
60	9·3178789		0·6821211	9·9904044		0·0095956	9.3274745		10·6725255	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin	Cotangent	D10″	Tangent	′

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·3178789	990	0·6821211	9·9904044	45	0·0095956	9·3274745	1035	10·6725255	60
1	9·3184728	988	0·6815272	9·9903775	45	0·0096225	9·3280953	1033	10·6719047	59
2	9·3190659	987	0·6809341	9·9903506	45	0·0096494	9·3287153	1032	10·6712847	58
3	9·3196581	986	0·6803419	9·9903237	45	0·0096763	9·3293345	1030	10·6706655	57
4	9·3202495	984	0·6797505	9·9902967	45	0·0097033	9·3299528	1029	10·6700472	56
5	9·3208400	983	0·6791600	9·9902697	45	0·0097303	9·3305704	1028	10·6694296	55
6	9·3214297	981	0·6785703	9·9902426	45	0·0097574	9·3311872	1027	10·6688128	54
7	9·3220186	980	0·6779814	9·9902155	45	0·0097845	9·3318031	1025	10·6681969	53
8	9·3226066	979	0·6773934	9·9901883	45	0·0098117	9·3324183	1024	10·6675817	52
9	9·3231938	977	0·6768062	9·9901612	45	0·0098388	9·3330327	1022	10·6669673	51
10	9·3237802	976	0·6762198	9·9901339	45	0·0098661	9·3336463	1021	10·6663537	50
11	9·3243657	975	0·6756343	9·9901067	45	0·0098933	9·3342591	1020	10·6657409	49
12	9·3249505	973	0·6750495	9·9900794	45	0·0099206	9·3348711	1019	10·6651289	48
13	9·3255344	972	0·6744656	9·9900521	46	0·0099479	9·3354823	1017	10·6645177	47
14	9·3261174	970	0·6738826	9·9900247	46	0·0099753	9·3360927	1016	10·6639073	46
15	9·3266997	969	0·6733003	9·9899973	46	0·0100027	9·3367024	1015	10·6632976	45
16	9·3272811	968	0·6727189	9·9899698	46	0·0100302	9·3373113	1014	10·6626887	44
17	9·3278617	966	0·6721383	9·9899423	46	0·0100577	9·3379194	1013	10·6620806	43
18	9·3284416	965	0·6715584	9·9899148	46	0·0100852	9·3385267	1011	10·6614733	42
19	9·3290206	963	0·6709794	9·9898873	46	0·0101127	9·3391333	1010	10·6608667	41
20	9·3295988	962	0·6704012	9·9898597	46	0·0101403	9·3397391	1008	10·6602609	40
21	9·3301761	961	0·6698239	9·9898320	46	0·0101680	9·3403441	1007	10·6596559	39
22	9·3307527	960	0·6692473	9·9898043	46	0·0101957	9·3409484	1006	10·6590516	38
23	9·3313285	958	0·6686715	9·9897766	46	0·0102234	9·3415519	1004	10·6584481	37
24	9·3319035	957	0·6680965	9·9897489	46	0·0102511	9·3421546	1003	10·6578454	36
25	9·3324777	956	0·6675223	9·9897211	46	0·0102789	9·3427566	1002	10·6572434	35
26	9·3330511	954	0·6669489	9·9896932	46	0·0103068	9·3433578	1001	10·6566422	34
27	9·3336237	953	0·6663763	9·9896654	46	0·0103346	9·3439583	999	10·6560417	33
28	9·3341955	952	0·6658045	9·9896374	47	0·0103626	9·3445580	998	10·6554420	32
29	9·3347665	950	0·6652335	9·9896095	47	0·0103905	9·3451570	997	10·6548430	31
30	9·3353368	949	0·6646632	9·9895815	47	0·0104185	9·3457552	996	10·6542448	30
31	9·3359062	948	0·6640938	9·9895535	47	0·0104465	9·3463527	994	10·6536473	29
32	9·3364749	946	0·6635251	9·9895254	47	0·0104746	9·3469494	993	10·6530506	28
33	9·3370428	945	0·6629572	9·9894973	47	0·0105027	9·3475454	992	10·6524546	27
34	9·3376099	944	0·6623901	9·9894692	47	0·0105308	9·3481407	991	10·6518593	26
35	9·3381762	943	0·6618238	9·9894410	47	0·0105590	9·3487352	990	10·6512648	25
36	9·3387418	941	0·6612582	9·9894128	47	0·0105872	9·3493290	988	10·6506710	24
37	9·3393065	940	0·6606935	9·9893845	47	0·0106155	9·3499220	987	10·6500780	23
38	9·3398706	939	0·6601294	9·9893562	47	0·0106438	9·3505143	986	10·6494857	22
39	9·3404338	938	0·6595662	9·9893279	47	0·0106721	9·3511059	985	10·6488941	21
40	9·3409963	936	0·6590037	9·9892995	47	0·0107005	9·3516968	984	10·6483032	20
41	9·3415580	935	0·6584420	9·9892711	47	0·0107289	9·3522869	982	10·6477131	19
42	9·3421190	934	0·6578810	9·9892427	47	0·0107573	9·3528763	981	10·6471237	18
43	9·3426792	932	0·6573208	9·9892142	48	0·0107858	9·3534650	980	10·6465350	17
44	9·3432386	931	0·6567614	9·9891856	48	0·0108144	9·3540530	979	10·6459470	16
45	9·3437973	930	0·6562027	9·9891571	48	0·0108429	9·3546402	977	10·6453598	15
46	9·3443552	929	0·6556448	9·9891285	48	0·0108715	9·3552267	976	10·6447733	14
47	9·3449124	927	0·6550876	9·9890998	48	0·0109002	9·3558126	975	10·6441874	13
48	9·3454688	926	0·6545312	9·9890711	48	0·0109289	9·3563977	974	10·6436023	12
49	9·3460245	925	0·6539755	9·9890424	48	0·0109576	9·3569821	973	10·6430179	11
50	9·3465794	924	0·6534206	9·9890137	48	0·0109863	9·3575658	971	10·6424342	10
51	9·3471336	922	0·6528664	9·9889849	48	0·0110151	9·3581487	970	10·6418513	9
52	9·3476870	921	0·6523130	9·9889560	48	0·0110440	9·3587310	969	10·6412690	8
53	9·3482397	920	0·6517603	9·9889271	48	0·0110729	9·3593126	968	10·6406874	7
54	9·3487917	919	0·6512083	9·9888982	48	0·0111018	9·3598935	967	10·6401065	6
55	9·3493429	917	0·6506571	9·9888693	48	0·0111307	9·3604736	966	10·6395264	5
56	9·3498934	916	0·6501066	9·9888403	48	0·0111597	9·3610531	965	10·6389469	4
57	9·3504432	915	0·6495568	9·9888113	48	0·0111887	9·3616319	963	10·6383681	3
58	9·3509922	914	0·6490078	9·9887822	48	0·0112178	9·3622100	962	10·6377900	2
59	9·3515405	913	0·6484595	9·9887531	49	0·0112469	9·3627874	961	10·6372126	1
60	9·3520880		0·6479120	9·9887239		0·0112761	9·3633641		10·6366359	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

13 Deg. Tab. 18.

′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·35[illegible]0	911	0·6479120	9·9887239	49	0·0112761	9·3633641	960	10·6366359	60
1	9·3[illegible]6349	910	0·6[illegible]651	[illegible]886947	49	0·0113053	9·3639401	959	10·6360599	59
2	9·3[illegible]1810	909	0·6468190	9·9886655	49	0·0113345	9·3645155	958	10·6[illegible]4845	58
3	9·3[illegible]37[illegible]4	908	0·6[illegible]2736	9·9886363	49	0·0113637	9·3650901	957	10·6349099	57
4	9·3542710	907	0·6457290	9·9886070	49	0·0[illegible]	9·36566[illegible]	956	10·6343359	[illegible]
5	9·[illegible]48150	906	0·6451850	9·9885776	49	0·011[illegible]	9·36623[illegible]	954	10·6337626	55
6	9·3553582	904	0·6446418	9·9885482	49	0·0114518	9·3668100	953	10·6331900	54
7	9·35[illegible]	903	0·6440993	9·9[illegible]518[illegible]	49	0·0114812	9·3673819	952	10·6326181	53
8	9·3564426	902	0·6435574	9·9884894	49	0·0115106	[illegible]679532	951	10·6320468	52
9	9·3569836	901	0·6430164	9·98845[illegible]	49	0·01[illegible]	9·3685238	950	10·6314762	51
10	9·3575[illegible]0	899	0·6424760	9·9884303	49	0·01[illegible]	9·3690937	949	10·6309063	50
11	9·3580637	898	0·[illegible]19363	9·9884008	49	0·011[illegible]	9·3696629	948	10·6[illegible]03371	49
12	9·3586027	897	0·[illegible]3973	9·98[illegible]71[illegible]	49	0·0116288	9·3702315	946	10·6297685	48
13	9·3591409	896	0·6408591	9·98[illegible]415	50	0·0116585	9·3707[illegible]4	945	10·6292006	47
14	9·3596785	895	0·6403215	9·9883118	50	0·0116882	9·37[illegible]667	944	10·6286333	46
15	9·3602154	894	0·6[illegible]97846	9·9882821	50	0·0117179	9·3719333	943	10·6280667	45
16	9·3607515	892	0·6392485	9·9882523	50	0·0117477	9·3724992	942	10·6275008	44
17	9·361[illegible]	891	0·6387130	9·9882225	50	0·01177[illegible]	9·3730645	941	10·626935[illegible]	[illegible]
18	9·36182[illegible]	890	0·6381783	9·9881927	50	0·0118073	9·3736291	940	10·6263709	42
19	9·36235[illegible]	889	0·6376442	9·9881628	50	0·0118372	9·3741930	939	10·6[illegible]070	41
20	9·3628892	888	0·6371108	9·9881329	50	0·0118671	9·3747563	938	10·62[illegible]37	40
21	9·3634219	887	0·6365781	9·9881029	50	0·0118971	9·3753190	937	10·6246810	39
22	9·3639539	885	0·6360461	9·9880729	50	0·0119271	9·3758810	936	10·6241190	38
23	9·3644852	884	0·6355148	9·9880429	50	0·0119571	9·3764423	935	10·6235577	37
24	9·3650158	883	0·6349842	9·9880128	50	0·0119872	9·3770030	933	10·6229970	36
25	9·3655458	882	0·6344542	9·9879827	50	0·0120173	9·3775631	932	10·6224369	35
26	9·3660750	881	0·6339250	9·9879525	50	0·0120475	9·3781225	931	10·6218775	34
27	9·3666036	880	0·6333964	9·9879223	50	0·0120777	9·3786818	930	10·6213187	33
28	9·3671315	879	0·6328685	9·9878921	50	0·0121079	9·3792394	929	10·6207606	32
29	9·3676587	877	0·6323413	9·9878618	50	0·0121382	9·3797969	928	10·6202031	31
30	9·3681853	876	0·6318147	9·9878315	50	0·0121685	9·3803537	927	10·6196463	30
31	9·3687111	875	0·6312889	9·9878012	51	0·0121988	9·3809100	926	10·6190900	29
32	9·3692363	874	0·6307637	9·9877708	51	0·0122292	9·3814655	925	10·6185345	28
33	9·3697608	873	0·6302392	9·9877404	51	0·0122596	9·3820205	924	10·6179795	27
34	9·3702847	872	0·6297153	9·9877099	51	0·0122901	9·3825748	923	10·6174252	26
35	9·3708079	871	0·6291921	9·9876794	51	0·0123206	9·3831285	922	10·6168[illegible]	25
36	9·3713304	870	0·6286696	9·9876488	51	0·0123517	9·3836816	921	10·616[illegible]184	24
37	9·3718523	869	0·6281477	9·9876183	51	0·0123817	9·3842340	920	10·6157660	23
38	9·3723735	868	0·6276265	9·9875876	51	0·0124124	9·3847858	919	10·6152142	22
39	9·3728940	867	0·6271060	9·9875570	51	0·0124430	9·3853370	918	10·6146630	21
40	9·3734139	865	0·6265861	9·9875263	51	0·0124737	9·3858876	917	10·6141124	20
41	9·3739331	864	0·6260669	9·9874955	51	0·0125045	9·3864376	916	10·6135624	19
42	9·3744517	863	0·6255483	9·9874648	51	0·0125352	9·3869869	914	10·6130131	18
43	9·3749696	862	0·6250304	9·9874339	51	0·0125661	9·3875356	913	10·6124644	17
44	9·3754868	861	0·6245132	9·9874031	51	0·0125969	9·3880837	912	10·6119163	16
45	9·3760034	860	0·6239966	9·9873722	51	0·0126278	9·3886312	911	10·6113688	15
46	9·3765194	859	0·6234806	9·9873413	52	0·0126587	9·3891781	910	10·6108219	14
47	9·37703[illegible]	858	0·622965[illegible]	9·9873103	52	0·0126897	9·3897244	909	10·6102756	13
48	9·3775493	857	0·6224507	9·9872793	52	0·0127207	9·3902700	908	10·6097300	12
49	9·3780633	856	0·6219367	9·9872482	52	0·0127518	9·3908151	907	10·6091849	11
50	9·3785767	855	0·6214233	9·9872171	52	0·0127829	9·3913595	906	10·6086405	10
51	9·3790894	853	0·6209106	9·9871860	52	0·0128140	9·3919034	905	10·6080966	9
52	9·3796015	852	0·6203985	9·9871549	52	0·0128451	9.3924466	904	10·6075534	8
53	9·3801129	851	0·6198871	9·9871236	52	0·0128764	9·3929893	903	10·6070107	7
54	9·3806237	850	0·6193763	9·9870924	52	0·0129076	9·39353[illegible]	902	10·6064687	6
55	9·3811339	849	0·618[illegible]	9·9870611	52	0·0129389	9·3940727	901	10·6059273	5
56	9·3816434	848	0·6183566	9·9870298	52	0·0129702	9·3946136	900	10·6053864	4
57	9·3821523	847	0·6178477	9·9869984	52	0·0130016	9·3951538	899	10·6048462	3
58	9·3826605	846	0·6173395	9·9869670	52	0·0130330	9·3956935	898	10·6043065	2
59	9·3831682	845	0·6168318	9·9869356	52	0·0130644	9·3962326	897	10·6037674	1
60	9·3836752		0·6163248	9·9869041		0·0130959	9·3967711		10·6032289	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin	Cotang.	D10″	Tangent	′

14 Deg. Tab. 18.

′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·3836752	844	0·6163248	9·9869041	52	0·0130959	9·396[illegible]	896	10·60[illegible]	60
1	9·3841815	843	0·6158185	9·98687[illegible]	53	0·01312[illegible]	9·39[illegible]	895	10·60[illegible]71	59
2	9·38[illegible]73	842	0·6153127	9·98684[illegible]	53	0·0131596	9·397[illegible]463	894	10·6021537	58
3	9·385192[illegible]	841	0·6148076	9·98680[illegible]	53	0·0131906	9·39[illegible]	893	10·60[illegible]78	57
4	9·38[illegible]969	840	0·6143031	[illegible]7778	53	0·0132222	9·3989191	892	10·60[illegible]809	56
5	9·38620[illegible]8	839	0·[illegible]137992	[illegible]67461	53	0·01325[illegible]	9·3994547	[illegible]	10·60[illegible]53	55
6	9·3867040	838	0·6132960	9·9867144	53	0·0132856	9·3999896	[illegible]	10·6000[illegible]	54
7	9·3872067	837	0·61279[illegible]3	9·9866827	53	0·01[illegible]173	9·4005210	890	10·59[illegible]760	53
8	9·3877087	836	0·612[illegible]	9·9866509	53	0·0133491	9·4010578	889	10·5989422	52
9	9·3882101	835	0·6117899	[illegible]66191	53	0·0133809	9·4015910	888	10·5984090	51
10	9·3887109	834	0·6112891	[illegible]5872	53	0·0134128	9·4021237	887	10·5978763	50
11	9·389[illegible]111	832	0·6107889	9·9865553	53	0·0134447	9·402[illegible]	886	10·5973442	49
12	9·3897106	831	0·6102894	9·98652[illegible]	53	0·01[illegible]767	9·40[illegible]	885	10·5968127	48
13	9·3902096	830	0·6097904	9·98649[illegible]	53	0·0135087	9·403[illegible]	884	10·5962818	47
14	9·3907079	829	0·60[illegible]2921	9·9864593	53	0·0135407	9·404[illegible]	883	10·5957514	46
15	9·3912057	828	0·6087943	9·9864273	53	0·0135727	9·4047[illegible]84	882	10·5952216	45
16	9·3917028	827	0·6082972	9·9863952	54	0·0136048	9·4053076	881	10·[illegible]6924	44
17	9·392199[illegible]	826	0·6078007	9·9863630	54	0·0136370	9·4058363	[illegible]	10·[illegible]1637	43
18	9·3926952	825	0·6073048	9·9863308	54	0·0136692	9·4063644	[illegible]	10·5936356	42
19	9·[illegible]1905	824	0·6068095	9·9862986	54	0·0137014	9·4068919	878	10·5931081	41
20	9·[illegible]6852	823	0·6063148	9·9862663	54	0·0137337	9·4074189	877	10·5925811	40
21	9·3941794	822	0·6058206	9·9862340	54	0·0137660	9·4079453	876	10·5920547	39
22	9·394[illegible]29	821	0·6053271	9·9862017	54	0·0137983	9·4084712	875	10·5915288	38
23	9·3951658	820	0·6048342	9·9861693	54	0·0138307	9·4089965	874	10·5910035	37
24	9·3956581	819	0·6043419	9·9861369	54	0·0138631	9·4095212	874	10·5904788	36
25	9·3961499	818	0·6038501	9·9861045	54	0·0138955	9·4100454	873	10·58995[illegible]	35
26	9·3966410	817	0·6033590	9·9860720	54	0·0139280	9·4105690	872	10·5894[illegible]	34
27	9·397131[illegible]	817	0·6028[illegible]	9·9860394	54	0·0139606	9·4110921	871	10·5889079	33
28	9·397[illegible]	816	0·6023785	9·9860069	54	0·0139931	9·4116146	870	10·5883854	32
29	9·3981[illegible]	814	0·601889[illegible]	9·9859742	54	0·0140258	9·4121366	869	10·587[illegible]634	31
30	9·3985996	814	0·6014004	9·9859416	54	0·0140584	9·41[illegible]81	868	10·5873419	30
31	9·3990878	813	0·6009122	9·9859089	54	0·0140911	9·413[illegible]	867	10·5868211	29
32	9·3995754	812	0·6004246	9·98587[illegible]	55	0·0141238	9·4136[illegible]	866	10·5863007	28
33	9·4000625	811	0·5999375	9·985843[illegible]	55	0·0141566	9·4142191	865	10·5857809	27
34	9·4005489	810	0·5994511	9·9858106	55	0·0141894	9·414[illegible]	864	10·5852617	26
35	9·4010348	809	0·5989652	9·9857777	55	0·0142223	9·41525[illegible]	863	10·5847430	25
36	9·4015201	808	0·5984799	9·9857449	55	0·0142551	9·415775[illegible]	863	10·5842248	24
37	9·4020048	807	0·5979952	9·9857119	55	0·0142881	9·416292[illegible]	862	10·5837072	23
38	9·4024889	806	0·5975111	9·9856790	55	0·0143210	9·4168099	861	10·5831901	22
39	9·4029724	805	0·5970276	9·9856460	55	0·0143540	9·4173265	860	10·5826735	21
40	9·4034554	804	0·5965446	9·9856129	55	0·0143871	9·4178425	859	10·5821575	20
41	9·4039378	803	0·5[illegible]0622	9·9855798	55	0·0144202	9·41[illegible]580	858	10·5816420	19
42	9·4044196	802	0·5955804	9·9855467	55	0·014453[illegible]	9·4188729	857	0·5811271	18
43	9·4049009	801	0·5950991	9·9855135	55	0·0144865	9·4193874	856	0·5806126	17
44	9·4053816	800	0·5946184	9·9854803	55	0·0145197	9·4199013	855	0·5800987	16
45	9·4058617	799	0·5941383	9·9854471	55	0·0145529	9·4204146	855	0·5795854	15
46	9·406341[illegible]	798	0·5936587	9·9854138	55	0·0145862	9·4209275	854	0·5790725	14
47	9·4068203	797	0·5931797	9·9853805	56	0·0146195	9·4214398	853	10·5785602	13
48	9·4072987	796	0·5927013	9·9853471	56	0·0146529	9·4219515	852	10·5780485	12
49	9·4077766	795	0·5922234	9·9853138	56	0·0146862	9·4224628	851	10·5775372	11
50	9·4082539	794	0·5917461	9·9852803	56	0·0147197	9·4229735	850	10·577026[illegible]	10
51	9·4087306	794	0·5912694	9·9852468	56	0·0147532	9·4234838	849	10·576516[illegible]	9
52	9·4092068	793	0·5907932	9·9852133	56	0·0147867	9·4239935	848	10·576006[illegible]	8
53	9·4096824	792	0·5903176	9·9851798	56	0·0148202	9·4245026	848	10·57497[illegible]	7
54	9·4101575	791	0·5898425	9·9851462	56	0·0148538	9·4250113	847	10·5749887	6
55	9·4106320	790	0·5893680	9·9851125	56	0·0148875	9·4255194	846	10·5744806	5
56	9·4111059	789	0·5888941	9·9850789	56	0·0149211	9·4260271	845	10·5739729	4
57	9·4115793	788	0·5884207	9·9850452	56	0·0149548	9·4265342	844	10·5734658	3
58	9·4120522	787	0·5879478	9·9850114	56	0·0149886	9·4270408	843	10·5729592	2
59	9·4125245	786	0·5874755	9·9849776	56	0·0140224	9·4275469	842	10·5724531	1
60	9·4129962		0·5870038	9·9849438		0·0140562	9·4280525		10·5719475	0
′	Cosine	D10″	Comp.cos	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

15 Deg. Tab. 18.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos	Tangent	D10″	Cotangent	′
0	9·4129962	785	0·5870038	9·9849438	56	0·0150562	9·4280525	842	10·5719475	60
1	9·4134674	784	0·5865326	9·9849099	56	0·0150901	9·4285575	841	10·5714425	59
2	9·4139381	783	0·5860619	9·9848760	57	0·0151240	9·4290621	840	10·5709379	58
3	9·4144082	782	0·5855918	9·9848420	57	0·0151580	9·4295661	839	10·5704339	57
4	9·4148778	781	0·5851222	9·9848061	57	0·0151919	9·4300697	838	10·5699303	56
5	9·4153468	780	0·5846532	9·9847740	57	0·0152260	9·4305727	838	10·5694273	55
6	9·4158152	780	0·5841848	9·9847400	57	0·0152600	9·4310753	837	10·5689247	54
7	9·4162832	779	0·5837168	9·9847059	57	0·0152941	9·4315773	836	10·5684227	53
8	9·4167506	778	0·5832494	9·9846717	57	0·0153283	9·4320789	835	10·5679211	52
9	9·4172174	777	0·5827826	9·9846375	57	0·0153625	9·4325799	834	10·5674201	51
10	9·4176837	776	0·5823163	9·9846033	57	0·0153967	9·4330804	833	10·5669196	50
11	9·4181495	775	0·5818505	9·9845690	57	0·0154310	9·4335805	832	10·5664195	49
12	9·4186148	774	0·5813852	9·9845347	57	0·0154653	9·4340800	832	10·5659200	48
13	9·4190795	773	0·5809205	9·9845004	57	0·0154996	9·4345791	831	10·5654209	47
14	9·4195436	773	0·5804564	9·9844660	57	0·0155340	9·4350776	830	10·5649224	46
15	9·4200073	772	0·5799927	9·9844316	57	0·0155684	9·4355757	829	10·5644243	45
16	9·4204704	771	0·5795296	9·9843971	57	0·0156029	9·4360733	828	10·5639267	44
17	9·4209330	770	0·5790670	9·9843626	57	0·0156374	9·4365704	828	10·5634296	43
18	9·4213950	769	0·5786050	9·9843281	58	0·0156719	9·4370670	827	10·5629330	42
19	9·4218566	768	0·5781434	9·9842935	58	0·0157065	9·4375631	826	10·5624369	41
20	9·4223176	767	0·5776824	9·9842589	58	0·0157411	9·4380587	825	10·5619413	40
21	9·4227780	766	0·5772220	9·9842242	58	0·0157758	9·4385538	824	10·5614462	39
22	9·4232380	765	0·5767620	9·9841895	58	0·0158105	9·4390485	824	10·5609515	38
23	9·4236974	765	0·5763026	9·9841548	58	0·0158452	9·4395426	823	10·5604574	37
24	9·4241563	764	0·5758437	9·9841200	58	0·0158800	9·4400363	822	10·5599637	36
25	9·4246147	763	0·5753853	9·9840852	58	0·0159148	9·4405295	821	10·5594705	35
26	9·4250726	762	0·5749274	9·9840503	58	0·0159497	9·4410222	820	10·5589778	34
27	9·4255299	761	0·5744701	9·9840154	58	0·0159846	9·4415145	820	10·5584855	33
28	9·4259867	760	0·5740133	9·9839805	58	0·0160195	9·4420062	819	10·5579938	32
29	9·4264430	760	0·5735570	9·9839455	58	0·0160545	9·4424975	818	10·5575025	31
30	9·4268988	759	0·5731012	9·9839105	58	0·0160895	9·4429883	817	10·5570117	30
31	9·4273541	758	0·5726459	9·9838755	59	0·0161245	9·4434786	816	10·5565214	29
32	9·4278089	757	0·5721911	9·9838404	59	0·0161596	9·4439685	816	10·5560315	28
33	9·4282631	756	0·5717369	9·9838052	59	0·0161948	9·4444579	815	10·5555421	27
34	9·4287169	755	0·5712831	9·9837701	59	0·0162299	9·4449468	814	10·5550532	26
35	9·4291701	754	0·5708299	9·9837348	59	0·0162652	9·4454352	813	10·5545648	25
36	9·4296228	754	0·5703772	9·9836996	59	0·0163004	9·4459232	813	10·5540768	24
37	9·4300750	753	0·5699250	9·9836643	59	0·0163357	9·4464107	812	10·5535893	23
38	9·4305267	752	0·5694733	9·9836290	59	0·0163710	9·4468978	811	10·5531022	22
39	9·4309779	751	0·5690221	9·9835936	59	0·0164064	9·4473843	810	10·5526157	21
40	9·4314286	750	0·5685714	9·9835582	59	0·0164418	9·4478704	809	10·5521296	20
41	9·4318788	749	0·5681212	9·9835227	59	0·0164773	9·4483561	809	10·5516439	19
42	9·4323285	749	0·5676715	9·9834872	59	0·0165128	9·4488413	808	10·5511587	18
43	9·4327777	748	0·5672223	9·9834517	59	0·0165483	9·4493260	808	10·5506740	17
44	9·4332264	747	0·5667736	9·9834161	59	0·0165839	9·4498102	807	10·5501898	16
45	9·4336746	746	0·5663254	9·9833805	59	0·0166195	9·4502940	806	10·5497060	15
46	9·4341223	745	0·5658777	9·9833449	59	0·0166551	9·4507774	805	10·5492226	14
47	9·4345694	744	0·5654306	9·9833092	60	0·0166908	9·4512602	804	10·5487398	13
48	9·4350161	744	0·5649839	9·9832735	60	0·0167265	9·4517427	803	10·5482573	12
49	9·4354623	743	0·5645377	9·9832377	60	0·0167623	9·4522246	802	10·5477754	11
50	9·4359080	742	0·5640920	9·9832019	60	0·0167981	9·4527061	802	10·5472939	10
51	9·4363532	741	0·5636468	9·9831661	60	0·0168339	9·4531872	801	10·5468128	9
52	9·4367980	740	0·5632020	9·9831302	60	0·0168698	9·4536678	800	10·5463322	8
53	9·4372422	740	0·5627578	9·9930942	60	0·0169058	9·4541479	799	10·5458521	7
54	9·4376859	739	0·5623141	9·9830583	60	0·0169417	9·4546276	799	10·5453724	6
55	9·4381292	738	0·5618708	9·9830223	60	0·0169777	9·4551069	798	10·5448931	5
56	9·4385719	737	0·5614281	9·9829862	60	0·0170138	9·4555857	797	10·5444143	4
57	9·4390142	736	0·5609858	9·9829501	60	0·0170499	9·4560641	796	10·5439359	3
58	9·4394560	735	0·5605440	9·9829140	60	0·0170860	9·4565420	796	10·5434580	2
59	9·4398973	734	0·5601027	9·9828778	60	0·0171222	9·4570194	795	10·5429806	1
60	9·4403381		0·5596619	9·9828416		0·0171584	9·4574964		10·5425036	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·4403381	734	0·5596619	9·9828416	60	0·0171584	9·45749[illegible]	[illegible]	10·542503[illegible]	60
1	9·4407784	733	0·5592216	9·9828054	60	0·0171946	9·4579[illegible]	[illegible]	10·5420270	59
2	9·4412182	732	0·5587818	9·9827691	60	0·0172309	9·4584491	793	10·5415509	58
3	9·4416576	731	0·5583424	9·9827328	61	0·0172672	9·4589248	792	10·5410752	57
4	9·4420965	731	0·5579035	9·9826964	61	0·0173036	9·4594001	791	10·5405999	56
5	9·4425349	730	0·5574651	9·9826600	61	0·0173400	9·4598749	790	10·5401251	55
6	9·4429728	729	0·5570272	9·9826236	61	0·0173764	9·4603492	789	10·5396508	54
7	9·4434103	728	0·5565897	9·9825871	61	0·0174129	9·4608232	789	10·5391768	53
8	9·4438472	727	0·5561528	9·9825506	61	0·0174494	9·4612967	788	10·5387033	52
9	9·4442837	727	0·5557163	9·9825140	61	0·0174860	9·4617697	788	10·5382303	51
10	9·4447197	726	0·5552803	9·9824774	61	0·0175226	9·4622423	787	10·5377577	50
11	9·4451553	725	0·5548447	9·9824408	61	0·0175592	9·4627145	786	10·5372855	49
12	9·4455904	724	0·5544096	9·9824041	61	0·0175959	9·4631863	786	10·5368137	48
13	9·4460250	724	0·5539750	9·9823674	61	0·0176326	9·4636576	785	10·5363424	47
14	9·4464591	723	0·5535409	9·9823306	61	0·0176694	9·4641285	784	10·5358715	46
15	9·4468927	722	0·5531073	9·9822938	61	0·0177062	9·4645990	783	10·5354010	45
16	9·4473259	721	0·5526741	9·9822569	62	0·0177431	9·4650690	782	10·5349310	44
17	9·4477586	720	0·5522414	9·9822201	62	0·0177799	9·4655386	782	10·5344614	43
16	9·4481909	720	0·5518091	9·9821831	62	0·0178169	9·4660078	781	10·5339922	42
19	9·4486227	719	0·5513773	9·9821462	62	0·0178538	9·4664765	780	10·5335235	41
20	9·4490540	718	0·5509460	9·9821092	62	0·0178908	9·4669448	780	10·5330552	40
21	9·4494849	717	0·5505151	9·9820721	62	0·0179279	9·4674127	779	10·5325873	39
22	9·4499153	716	0·5500847	9·9820351	62	0·0179649	9·4678802	778	10·5321198	38
23	9·4503452	716	0·5496548	9·9819979	62	0·0180021	9·4683473	778	10·5316527	37
24	9·4507747	715	0·5492253	9·9819608	62	0·0180392	9·4688139	777	10·5311861	36
25	9·4512037	714	0·5487963	9·9819236	62	0·0180764	9·4692801	776	10·5307199	35
26	9·4516322	713	0·5483678	9·9818863	62	0·0181137	9·4697459	775	10·5302541	34
27	9·4520603	713	0·5479397	9·9818490	62	0·0181510	9·4702112	775	10·5297888	33
28	9·4524879	712	0·5475121	9·9818117	62	0·0181883	9·4706762	774	10·5293238	32
29	9·4529151	711	0·5470849	9·9817744	62	0·0182256	9·4711407	773	10·5288593	31
30	9·4533418	710	0·5466582	9·9817370	62	0·0182630	9·4716048	773	10·5283952	30
31	9·4537681	710	0·5462319	9·9816995	62	0·0183005	9·4720685	772	10·5279315	29
32	9·4541939	709	0·5458061	9·9816620	62	0·0183380	9·4725318	771	10·5274682	28
33	9·4546192	708	0·5453808	9·9816245	62	0·0183755	9·4729947	771	10·5270053	27
34	9·4550441	707	0·5449559	9·9815870	63	0·0184130	9·4734571	770	10·5265428	26
35	9·4554686	707	0·5445314	9·9815494	63	0·0184506	9·4739192	769	10·5260808	25
36	9·4558926	706	0·5441074	9·9815117	63	0·0184883	9·4743808	769	10·5256192	24
37	9·4563161	705	0·5436839	9·9814740	63	0·0185260	9·4748421	768	10·5251579	23
38	9·4567392	704	0·5432608	9·9814362	63	0·0185637	9·4753029	767	10·5246971	22
39	9·4571618	704	0·5428382	9·9813986	63	0·0186014	9·4757633	766	10·5242367	21
40	9·4575840	703	0·5424160	9·9913608	63	0·0186392	9·4762233	766	10·5237767	20
41	9·4580058	702	0·5419942	9·9813229	63	0·0186771	9·4766829	765	10·5233171	19
42	9·4584271	701	0·5415729	9·9812850	63	0·0187150	9·4771421	765	10·5228579	18
43	9·4588480	700	0·5411520	9·9812471	63	0·0187529	9·4776009	764	10·5223991	17
44	9·4592684	700	0·5407316	9·9812091	63	0·0187909	9·4780592	763	10·5219408	16
45	9·4596884	699	0·5403116	9·9811711	63	0·0188289	9·4785172	763	10·5214828	15
46	9·4601079	699	0·5398921	9·9811331	63	0·0188669	9·4789748	762	10·5210252	14
47	9·4605270	698	0·5394730	9·9810950	63	0·0189050	9·4794319	761	10·5205681	13
48	9·4609456	697	0·5390544	9·9810569	64	0·0189431	9·4798887	761	10·5201113	12
49	9·4613638	696	0·5386362	9·9810187	64	0·0189813	9·4803451	760	10·5196549	11
50	9·4617816	696	0·5382184	9·9809805	64	0·0190195	9·4808011	759	10·5191989	10
51	9·4621989	695	0·5378011	9·9809423	64	0·0190577	9·4812566	759	10·5187434	9
52	9·4626158	694	0·5373842	9·9809040	64	0·0190960	9·4817118	758	10·5182882	8
53	9·4630323	693	0·5369677	9·9808657	64	0·0191343	9·4821666	757	10·5178334	7
54	9·4634483	693	0·5365517	9·9808273	64	0·0191727	9·4826210	756	10·5173790	6
55	9·4638639	692	0·5361361	9·9807889	64	0·0192111	9·4830750	755	10·5169250	5
56	9·4642790	691	0·5357210	9·9807505	64	0·0192495	9·4835286	755	10·5164714	4
57	9·4646938	690	0·5353062	9·9807120	64	0·0192880	9·4839818	755	10·5160182	3
58	9·4651084	690	0·5348916	9·9806735	64	0·0193265	9·4844346	754	10·5155654	2
59	9·4655219	689	0·5344781	9·9806349	64	0·0193651	9·4848870	753	10·5151130	1
60	9·4659353		0·5340647	9·9805963		0·0194037	9·4853390		10·5146610	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotangent	D10″	Tangent	′

17 Deg.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent.	′
0	9·4659353	[illegible]	0·5340647	9·9805963	64	0·0194037	9·4853390	753	10·5146610	60
1	9·4663483	[illegible]	[illegible]	9·9805577	64	0·0194423	9·4857907	752	10·5142093	59
2	9·4667609	687	0·5332391	9·9805190	64	0·0194810	9·4862419	752	10·5137581	58
3	9·4671730	686	0·5328270	9·9804808	65	0·0195192	9·4866928	751	10·5133072	57
4	9·4675848	685	0·5324152	9·9804415	65	0·0195585	9·4871433	750	10·5128567	56
5	9·4679960	685	0·5320040	9·9804027	65	0·0195973	9·4875933	749	10·5124067	55
6	9·4684068	684	0·5315932	9·9803639	65	0·0196361	9·4880430	749	10·5119570	54
7	9·4688173	683	0·5311827	9·9803250	65	0·0196750	9·4884924	748	10·5115076	53
8	9·4692273	683	0·5307727	9·9802860	65	0·0197140	9·4889413	747	10·5110587	52
9	9·4696369	682	0·5303631	9·9802471	65	0·0197529	9·4893898	747	10·5106102	51
10	9·4700461	681	0·5299539	9·9802081	65	0·0197919	9·4898380	746	10·5101620	50
11	9·4704548	680	0·5295452	9·9801690	65	0·0198310	9·4902858	745	10·5097142	49
12	9·4708631	680	0·5291369	9·9801299	65	0·0198701	9·4907332	745	10·5092668	48
13	9·4712710	679	0·5287290	9·9800908	66	0·0199092	9·4911802	744	10·5088198	47
14	9·4716785	678	0·5283215	9·9800516	66	0·0199484	9·4916269	744	10·5083731	46
15	9·4720856	678	0·5279144	9·9800124	66	0·0199876	9·4920731	743	10·5079269	45
16	9·4724922	677	0·5275078	9·9799732	66	0·0200268	9·4925190	743	10·5074810	44
17	9·4728985	676	0·5271015	9·9799339	66	0·0200661	9·4929646	742	10·5070354	43
18	9·4733043	676	0·5266957	9·9798946	66	0·0201054	9·4934097	741	10·5065903	42
19	9·4737097	675	0·5262903	9·9798552	66	0·0201448	9·4938545	740	10·5061455	41
20	9·4741146	674	0·5258854	9·9798158	66	0·0201842	9·4942988	740	10·5057012	40
21	9·4745192	673	0·5254808	9·9797764	66	0·0202236	9·4947429	739	10·5052571	39
22	9·4749234	673	0·5250766	9·9797369	66	0·0202631	9·4951865	739	10·5048135	38
23	9·4753271	672	0·5246729	9·9796973	66	0·0203027	9·4956298	738	10·5043702	37
24	9·4757304	671	0·5242696	9·9796578	66	0·0203422	9·4960727	737	10·5039273	36
25	9·4761334	671	0·5238666	9·9796182	66	0·0203818	9·4965152	737	10·5034848	35
26	9·4765359	670	0·5234641	9·9795785	66	0·0204215	9·4969574	736	10·5030426	34
27	9·4769380	669	0·5230620	9·9795388	66	0·0204612	9·4973991	736	10·5026009	33
28	9·4773396	669	0·5226604	9·9794991	66	0·0205009	9·4978406	735	10·5021594	32
29	9·4777409	668	0·5222591	9·9794593	66	0·0205407	9·4982816	734	10·5017184	31
30	9·4781418	667	0·5218582	9·9794195	66	0·0205805	9·4987223	734	10·5012777	30
31	9·4785423	667	0·5214577	9·9793796	66	0·0206204	9·4991626	733	10·5008374	29
32	9·4789423	666	0·5210577	9·9793398	67	0·0206602	9·4996026	733	10·5003974	28
33	9·4793420	665	0·5206580	9·9792998	67	0·0207002	9·5000422	732	10·4999578	27
34	9·4797412	665	0·5202588	9·9792599	67	0·0207401	9·5004814	731	10·4995186	26
35	9·4801401	664	0·5198599	9·9792198	67	0·0207802	9·5009203	731	10·4990797	25
36	9·4805385	663	0·5194615	9·9791798	67	0·0208202	9·5013588	730	10·4986412	24
37	9·4809366	663	0·5190634	9·9791397	67	0·0208603	9·5017969	730	10·4982031	23
38	9·4813342	662	0·5186658	9·9790996	67	0·0209004	9·5022347	729	10·4977653	22
39	9·4817315	661	0·5182685	9·9790594	67	0·0209406	9·5026721	728	10·4973279	21
40	9·4821283	661	0·5178717	9·9790192	67	0·0209808	9·5031092	728	10·4968908	20
41	9·4825248	660	0·5174752	9·9789789	67	0·0210211	9·5035459	727	10·4964541	19
42	9·4829208	659	0·5170792	9·9789386	67	0·0210614	9·5039822	727	10·4960178	18
43	9·4833165	659	0·5166835	9·9788983	67	0·0211017	9·5044182	726	10·4955818	17
44	9·4837117	658	0·5162883	9·9788579	67	0·0211421	9·5048538	725	10·4951462	16
45	9·4841066	657	0·5158934	9·9788175	67	0·0211825	9·5052891	725	10·4947109	15
46	9·4845010	657	0·5154990	9·9787770	67	0·0212230	9·5057240	724	10·4942760	14
47	9·4848951	656	0·5151049	9·9787365	67	0·0212635	9·5061586	724	10·4938414	13
48	9·4852888	655	0·5147112	9·9786960	68	0·0213040	9·5065928	723	10·4934072	12
49	9·4856820	655	0·5143180	9·9786554	68	0·0213446	9·5070267	722	10·4929733	11
50	9·4860749	654	0·5139251	9·9786148	68	0·0213852	9·5074602	722	10·4925398	10
51	9·4864674	653	0·5135326	9·9785741	68	0·0214259	9·5078933	721	10·4921067	9
52	9·4868595	653	0·5131405	9·9785334	68	0·0214666	9·5083261	721	10·4916739	8
53	9·4872512	652	0·5127488	9·9784927	68	0·0215073	9·5087586	720	10·4912414	7
54	9·4876426	651	0·5123574	9·9784519	68	0·0215481	9·5091907	719	10·4908093	6
55	9·4880335	651	0·5119665	9·9784111	68	0·0215889	9·5096224	719	10·4903776	5
56	9·4884240	650	0·5115760	9·9783702	68	0·0216298	9·5100539	718	10·4899461	4
57	9·4888142	649	0·5111858	9·9783293	68	0·0216707	9·5104849	718	10·4895151	3
58	9·4892040	649	0·5107960	9·9782883	68	0·0217117	9·5109156	717	10·4890844	2
59	9·4895934	648	0·5104066	9·9782474	68	0·0217526	9·5113460	717	10·4886540	1
60	9·4899824		0·5100176	9·9782063		0·0217937	9·5117760		10·4882240	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·4899824	648	0·5100176	9·9782069	68	0·0217[illegible]	9·5117[illegible]	[illegible]	[illegible]	60
1	9·4903710	647	0·5096290	9·9781653	68	0·0218347	9·512[illegible]	[illegible]	10·4877[illegible]	59
2	9·4907592	646	0·5092408	9·9781241	69	0·0218759	[illegible]	[illegible]	[illegible]	58
3	9·49[illegible]71	645	0·5088529	9·9780830	69	0·0219170	[illegible]	714	10·4869359	57
4	9·4915345	645	0·50846[illegible]	9·9780418	69	0·0219582	[illegible]	714	[illegible]	56
5	9·4919216	644	0·5080784	9·9780006	69	0·02199[illegible]	[illegible]	[illegible]	[illegible]	55
6	9·4923083	644	0·5076917	9·9779593	69	0·0220407	9·5143490	[illegible]	[illegible]	54
7	9·4926946	643	0·5073054	9·9779180	69	[illegible]	9·5147760	[illegible]	[illegible]	53
8	9·4930806	642	0·5069194	9·9778766	69	0·0221234	9·5152039	712	[illegible]	52
9	9·4934661	642	0·5065339	9·9778353	69	0·0221647	9·5156309	[illegible]	10·4843691	51
10	9·4938513	641	0·5061487	9·9777938	69	0·0222062	9·5160575	710	10·4839425	50
11	9·4942361	641	0·5057639	9·9777523	69	0·0222477	9·5164838	710	10·4835162	49
12	9·4946205	640	0·5053795	9·9777[illegible]	69	0·0222892	[illegible]	709	10·483[illegible]	48
13	9·4950046	639	0·5049954	9·977[illegible]	69	0·0223307	9·517[illegible]	709	10·4826647	47
14	9·4953883	639	0·5046117	9·9776277	69	0·0223723	9·5177606	708	10·4822394	46
15	9·4957716	638	0·5042284	9·9775860	69	0·0224140	9·5181855	708	10·4818145	45
16	9·4961545	637	0·5038455	9·9775444	70	0·0224556	9·5186101	707	10·4813899	44
17	9·4965370	637	0·5034630	9·9775026	70	0·0224974	9·5190344	[illegible]	10·4809656	43
18	9·4969192	636	0·5030808	9·9774609	70	0·0225391	9·5194583	[illegible]	10·4805417	42
19	9·4973010	636	0·5026990	9·9774191	70	0·0225809	9·5198819	706	10·4801181	41
20	9·4976824	635	0·5023176	9·9773772	70	0·0226228	9·5203052	705	10·4796948	40
21	9·4980635	634	0·5019365	9·9773354	70	0·0226646	9·5207282	704	10·4792718	39
22	9·4984442	634	0·5015558	9·9772934	70	0·0227066	9·5211508	704	10·4788492	38
23	9·4988245	633	0·5011755	9·9772515	70	0·0227485	9·5215730	703	10·4784270	37
24	9·4992045	632	0·5007955	9·9772095	70	0·0227905	9·5219950	703	10·4780050	36
25	9·4995840	632	0·5004160	9·9771674	70	0·0228326	9·5224166	702	10·4775834	35
26	9·4999633	631	0·5000367	9·9771253	70	0·0228747	9·5228379	702	10·4771621	34
27	9·5003421	631	0·4996579	9·9770832	70	0·0229168	6·5232589	701	10·4767411	33
28	9·5007206	630	0·4992794	9·9770410	70	0·0229590	9·5236795	701	10·4763[illegible]	32
29	9·5010987	629	0·4989013	9·9769988	70	0·0230012	9·5240999	700	10·4759001	31
30	9·5014764	629	0·4985236	9·9769566	70	0·0230434	9·5245199	699	10·4754801	30
31	9·5018538	628	0·4981462	9·9769143	70	0·0230857	9·5249395	699	10·4750605	29
32	9·5022308	628	0·4977692	9·9768720	71	0·0231280	9·5253589	698	10·4746411	28
33	9·5026075	627	0·4973925	9·9768296	71	0·0231704	9·5257779	698	10·4742221	27
34	9·5029838	626	0·4970162	9·9767872	71	0·0232128	9·5261[illegible]	[illegible]	10·4738034	26
35	9·5033597	626	0·4966403	9·9767447	71	0·0232553	9·5266150	697	10·4733850	25
36	9·5037353	625	0·4962647	9·9767022	71	0·0232978	9·5270331	696	10·4729669	24
37	9·5041105	625	0·4958895	9·9766597	71	0·0233403	9·5274508	696	10·4725492	23
38	9·5044853	624	0·4955147	9·9766171	71	0·0233829	9·5278682	695	10·4721318	22
39	9·5048598	623	0·4951402	9·9765745	71	0·0234255	9·5282853	695	10·4717147	21
40	9·5052339	623	0·4947661	9·9765318	71	0·0234682	9·5287021	694	10·4712979	20
41	9·5056077	622	0·4943923	9·9764891	71	0·0235109	9·5291186	693	10·4708814	19
42	9·5059811	622	0·4940189	9·9764464	71	0·0235536	9·5295347	693	10·4704653	18
43	9·5063542	621	0·4936458	9·9764036	71	0·0235965	9·5299505	692	10·4700495	17
44	9·5067269	620	0·4932731	9·9763608	71	0·0236392	9·5303661	692	10·4696339	16
45	9·5070992	620	0·4929008	9·9763179	71	0·0236821	9·5307813	691	10·4692187	15
46	9·5074712	619	0·4925288	9·9762750	71	0·0237250	9·5311961	691	10·4688039	14
47	9·5078428	619	0·4921572	9·9762321	72	0·0237679	9·5316107	690	10·4683893	13
48	9·5082141	618	0·4917859	9·9761891	72	0·0238109	9·5320250	690	10·4679750	12
49	9·5085850	618	0·4914150	9·9761461	72	0·0238539	9·5324389	689	10·4675611	11
50	9·5089556	617	0·4910444	9·9761030	72	0·0238970	9·5328526	689	10·4671474	10
51	9·5093258	616	0·4906742	9·9760599	72	0·0239401	9·5332659	688	10·4667341	9
52	9·5096956	616	0·4903044	9·9760167	72	0·0239833	9·5336789	688	10·4663211	8
53	9·5100651	615	0·4899349	9·9759736	72	0·0240264	9·5340916	687	10·4659084	7
54	9·5104343	615	0·4895657	9·9759303	72	0·0240697	9·5345040	687	10·4654960	6
55	9·5108031	614	0·4891969	9·9758870	72	0·0241130	9·5349161	686	10·4650839	5
56	9·5111716	613	0·4888284	9·9758437	72	0·0241563	9·5353278	686	10·4646722	4
57	9·5115397	613	0·4884603	9·9758004	72	0·0241996	9·5357393	685	10·4642607	3
58	9·5119074	612	0·4880926	9·9757570	72	0·0242430	9·5361505	685	10·4638495	2
59	9·5122749	612	0·4877251	9·9757135	72	0·0242865	9·5365613	684	10·4634387	1
60	9·5126419		0·4873581	9·9756701		0·0243299	9·5369719		10·4630281	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

19 Deg. Tab. 18.

′	Sine.	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·5126419	611	0·4873581	9·9756701	73	0·0243299	9·5369719	684	10·4630281	60
1	9·5130086	611	0·4869914	9·9756265	73	0·0243735	9·5373821	683	10·4626179	59
2	9·5133750	610	0·4866250	9·9755830	73	0·0244170	9·5377920	683	10·4622080	58
3	9·5137410	609	0·4862590	9·9755394	73	0·0244606	9·5382017	682	10·4617983	57
4	9·5141067	609	0·4858933	9·9754957	73	0·0245043	9·5386110	682	10·4613890	56
5	9·5144721	608	0·4855279	9·9754521	73	0·0245479	9·5390200	681	10·4609800	55
6	9·5148371	608	0·4851629	9·9754083	73	0·0245917	9·5394287	681	10·4605713	54
7	9·5152017	607	0·4847983	9·9753646	73	0·0246354	9·5398371	680	10·4601629	53
8	9·5155660	607	0·4844340	9·9753208	73	0·0246792	9·5402453	680	10·4597547	52
9	9·5159300	606	0·4840700	9·9752769	73	0·0247231	9·5406531	679	10·4593469	51
10	9·5162936	605	0·4837064	9·9752330	73	0·0247670	9·5410606	679	10·4589394	50
11	9·5166569	605	0·4833431	9·9751891	73	0·0248109	9·5414678	678	10·4585322	49
12	9·5170198	604	0·4829802	9·9751451	73	0·0248549	9·5418747	678	10·4581253	48
13	9·5173824	604	0·4826176	9·9751011	73	0·0248989	9·5422813	677	10·4577187	47
14	9·5177447	603	0·4822553	9·9750570	73	0·0249430	9·5426877	677	10·4573123	46
15	9·5181066	603	0·4818934	9·9750129	73	0·0249871	9·5430937	676	10·4569063	45
16	9·5184682	602	0·4815318	9·9749688	74	0·0250312	9·5434994	676	10·4565006	44
17	9·5188295	601	0·4811705	9·9749246	74	0·0250754	9·5439048	675	10·4560952	43
18	9·5191904	601	0·4808096	9·9748804	74	0·0251196	9·5443100	675	10·4556900	42
19	9·5195510	600	0·4804490	9·9748361	74	0·0251639	9·5447146	674	10·4552852	41
20	9·5199112	600	0·4800888	9·9747918	74	0·0252082	9·5451193	674	10·4548807	40
21	9·5202711	599	0·4797289	9·9747475	74	0·0252525	9·5455236	673	10·4544764	39
22	9·5206307	599	0·4793693	9·9747031	74	0·0252969	9·5459276	673	10·4540724	38
23	9·5209899	598	0·4790101	9·9746587	74	0·0253413	9·5463312	672	10·4536688	37
24	9·5213488	598	0·4786512	9·9746142	74	0·0253858	9·5467346	672	10·4532654	36
25	9·5217074	597	0·4782926	9·9745697	74	0·0254303	9·5471377	671	10·4528623	35
26	9·5220656	596	0·4779344	9·9745252	74	0·0254748	9·5475405	671	10·4524595	34
27	9·5224235	596	0·4775765	9·9744806	74	0·0255194	9·5479430	670	10·4520570	33
28	9·5227811	595	0·4772189	9·9744359	74	0·0255641	9·5483452	670	10·4516548	32
29	9·5231383	595	0·4768617	9·9743913	74	0·0256087	9·5487471	669	10·4512529	31
30	9·5234953	594	0·4765047	9·9743466	75	0·0256534	9·5491487	669	10·4508513	30
31	9·5238518	594	0·4761482	9·9743018	75	0·0256982	9·5495500	668	10·4504500	29
32	9·5242081	593	0·4757919	9·9742570	75	0·0257430	9·5499511	668	10·4500489	28
33	9·5245640	593	0·4754360	9·9742122	75	0·0257878	9·5503519	667	10·4496481	27
34	9·5249196	592	0·4750804	9·9741673	75	0·0258327	9·5507523	667	10·4492477	26
35	9·5252749	591	0·4747251	9·9741224	75	0·0258776	9·5511525	666	10·4488475	25
36	9·5256298	591	0·4743702	9·9740774	75	0·0259226	9·5515524	666	10·4484476	24
37	9·5259844	590	0·4740156	9·9740324	75	0·0259676	9·5519521	665	10·4480479	23
38	9·5263387	590	0·4736613	9·9739873	75	0·0260127	9·5523514	665	10·4476486	22
39	9·5266927	589	0·4733073	9·9739422	75	0·0260578	9·5527504	665	10·4472496	21
40	9·5270463	589	0·4729537	9·9738971	75	0·0261029	9·5531492	664	10·4468508	20
41	9·5273997	588	0·4726003	9·9738519	75	0·0261481	9·5535477	664	10·4464523	19
42	9·5277526	588	0·4722474	9·9738067	75	0·0261933	9·5539459	663	10·4460541	18
43	9·5281053	587	0·4718947	9·9737615	75	0·0262385	9·5543438	663	10·4456562	17
44	9·5284577	587	0·4715423	9·9737162	75	0·0262838	9·5547415	662	10·4452585	16
45	9·5288097	586	0·4711903	9·9736709	76	0·0263291	9·5551388	662	10·4448612	15
46	9·5291614	586	0·4708386	9·9736255	76	0·0263745	9·5555359	661	10·4444641	14
47	9·5295128	585	0·4704872	9·9735801	76	0·0264199	9·5559327	661	10·4440673	13
48	9·5298638	585	0·4701362	9·9735346	76	0·0264654	9·5563292	660	10·4436708	12
49	9·5302146	584	0·4697854	9·9734891	76	0·0265109	9·5567255	660	10·4432745	11
50	9·5305650	583	0·4694350	9·9734435	76	0·0265565	9·5571214	659	10·4428786	10
51	9·5309151	583	0·4690849	9·9733980	76	0·0266020	9·5575171	659	10·4424829	9
52	9·5312649	582	0·4687351	9·9733523	76	0·0266477	9·5579125	659	10·4420875	8
53	9·5316143	582	0·4683857	9·9733067	76	0·0266933	9·5583077	658	10·4416923	7
54	9·5319635	581	0·4680365	9·9732610	76	0·0267390	9·5587025	658	10·4412975	6
55	9·5323123	581	0·4676877	9·9732152	76	0·0267848	9·5590971	657	10·4409029	5
56	9·5326608	580	0·4673392	9·9731694	76	0·0268306	9·5594914	657	10·4405086	4
57	9·5330090	580	0·4669910	9·9731236	76	0·0268764	9·5598854	656	10·4401146	3
58	9·5333569	579	0·4666431	9·9730777	76	0·0269223	9·5602792	656	10·4397208	2
59	9·5337044	579	0·4662956	9·9730318	77	0·0269682	9·5606727	655	10·4393273	1
60	9·5340517		0·4659483	9·9729858		0·0270142	9·5610659		10·4389341	0
′	Cosine.	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp. sin.	Cosine	D10″	Com. sec.	Tangent	D10″	Cotangent	′
0	9·5340517	578	0·4659483	9·9729858	77	0·0270142	9·5610659	655	10·4389341	60
1	9·5343986	576	0·4656014	9·9729398	77	0·0270602	9·5614589	654	10·4385411	59
2	9·5347453	577	0·4652548	9·9728938	77	0·0271062	9·5618515	654	10·4381485	58
3	9·5350915	577	0·4649085	9·9728477	77	0·0271523	9·5622439	653	10·4377561	57
4	9·5354375	576	0·4645625	9·9728016	77	0·0271984	9·5626366	653	10·4373634	56
5	9·5357832	576	0·4642168	9·9727554	77	0·0272446	9·5630278	653	10·4369722	55
6	9·5361286	575	0·4638714	9·9727092	77	0·0272908	9·5634194	652	10·4365806	54
7	9·5364737	574	0·4635263	9·9726629	77	0·0273371	9·5638107	652	10·4361893	53
8	9·5368184	574	0·4631816	9·9726166	77	0·0273834	9·5642016	651	10·4357984	52
9	9·5371629	573	0·4628371	9·9725703	77	0·0274297	9·5645925	651	10·4354075	51
10	9·5375070	573	0·4624930	9·9725239	77	0·0274761	9·5649831	650	10·4350169	50
11	9·5378508	572	0·4621492	9·9724775	77	0·0275225	9·5653733	650	10·4346267	49
12	9·5381943	572	0·4618057	9·9724310	77	0·0275690	9·5657633	649	10·4342367	48
13	9·5385375	571	0·4614625	9·9723845	77	0·0276155	9·5661530	649	10·4338470	47
14	9·5388804	571	0·4611196	9·9723380	78	0·0276620	9·5665424	649	10·4334576	46
15	9·5392230	570	0·4607770	9·9722914	78	0·0277086	9·5669316	648	10·4330684	45
16	9·5395653	570	0·4604347	9·9722448	78	0·0277552	9·5673205	648	10·4326795	44
17	9·5399073	569	0·4600927	9·9721981	78	0·0278019	9·5677091	647	10·4322909	43
18	9·5402489	569	0·4597511	9·9721514	78	0·0278486	9·5680975	647	10·4319025	42
19	9·5405903	568	0·4594097	9·9721047	78	0·0278953	9·5684856	646	10·4315144	41
20	9·5409314	568	0·4590686	9·9720579	78	0·0279421	9·5688735	646	10·4311265	40
21	9·5412721	567	0·4587279	9·9720110	78	0·0279890	9·5692611	645	10·4307389	39
22	9·5416126	567	0·4583874	9·9719642	78	0·0280358	9·5696484	645	10·4303516	38
23	9·5419527	566	0·4580473	9·9719172	78	0·0280828	9·5700355	645	10·4299645	37
24	9·5422926	566	0·4577074	9·9718703	78	0·0281297	9·5704223	644	10·4295777	36
25	9·5426321	565	0·4573679	9·9718233	78	0·0281767	9·5708088	644	10·4291912	35
26	9·5429713	565	0·4570287	9·9717762	78	0·0282238	9·5711951	643	10·4288049	34
27	9·5433103	564	0·4566897	9·9717291	78	0·0282709	9·5715811	643	10·4284189	33
28	9·5436489	564	0·4563511	9·9716820	79	0·0283180	9·5719669	642	10·4280331	32
29	9·5439873	563	0·4560127	9·9716348	79	0·0283652	9·5723524	642	10·4276476	31
30	9·5443253	563	0·4556747	9·9715876	79	0·0284124	9·5727377	642	10·4272623	30
31	9·5446630	562	0·4553370	9·9715404	79	0·0284596	9·5731227	641	10·4268773	29
32	9·5450005	562	0·4549995	9·9714931	79	0·0285069	9·5735074	641	10·4264926	28
33	9·5453376	561	0·4546624	9·9714457	79	0·0285543	9·5738919	640	10·4261081	27
34	9·5456745	561	0·4543255	9·9713984	79	0·0286016	9·5742761	640	10·4257239	26
35	9·5460110	560	0·4539890	9·9713509	79	0·0286491	9·5746601	639	10·4253399	25
36	9·5463472	560	0·4536528	9·9713035	79	0·0286965	9·5750438	639	10·4249562	24
37	9·5466831	559	0·4533168	9·9712560	79	0·0287440	9·5754272	639	10·4245728	23
38	9·5470189	559	0·4529811	9·9712084	79	0·0287916	9·5758104	638	10·4241896	22
39	9·5473542	558	0·4526458	9·9711608	79	0·0288392	9·5761934	638	10·4238066	21
40	9·5476893	558	0·4523107	9·9711132	79	0·0288868	9·5765761	637	10·4234239	20
41	9·5480240	557	0·4519760	9·9710655	79	0·0289345	9·5769585	637	10·4230415	19
42	9·5483585	557	0·4516415	9·9710178	80	0·0289822	9·5773407	636	10·4226593	18
43	9·5486927	556	0·4513073	9·9709701	80	0·0290299	9·5777226	636	10·4222774	17
44	9·5490266	556	0·4509734	9·9709223	80	0·0290777	9·5781043	636	10·4218957	16
45	9·5493603	555	0·4506398	9·9708744	80	0·0291256	9·5784858	635	10·4215142	15
46	9·5496935	555	0·4503065	9·9708265	80	0·0291735	9·5788669	635	10·4211331	14
47	9·5500265	554	0·4499735	9·9707786	80	0·0292214	9·5792479	634	10·4207521	13
48	9·5503593	554	0·4496408	9·9707306	80	0·0292694	9·5796286	634	10·4203714	12
49	9·5506916	553	0·4493084	9·9706826	80	0·0293174	9·5800090	634	10·4199910	11
50	9·5510237	553	0·4489763	9·9706346	80	0·0293654	9·5803892	633	10·4196108	10
51	9·5513556	552	0·4486444	9·9705865	80	0·0294135	9·5807691	633	10·4192309	9
52	9·5516871	552	0·4483129	9·9705383	80	0·0294617	9·5811488	632	10·4188512	8
53	9·5520184	552	0·4479816	9·9704902	80	0·0295098	9·5815282	632	10·4184718	7
54	9·5523494	551	0·4476506	9·9704419	80	0·0295581	9·5819074	632	10·4180926	6
55	9·5526801	551	0·4473199	9·9703937	80	0·0296063	9·5822864	631	10·4177136	5
56	9·5530105	550	0·4469895	9·9703454	81	0·0296546	9·5826651	631	10·4173349	4
57	9·5533406	550	0·4466594	9·9702970	81	0·0297030	9·5830435	630	10·4169565	3
58	9·5536704	549	0·4463296	9·9702486	81	0·0297514	9·5834217	630	10·4165783	2
59	9·5539999	549	0·4460001	9·9702002	81	0·0297998	9·5837997	629	10·4162003	1
60	9·5543292		0·4456708	9·9701517		0·0298483	9·5841774		10·4158226	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

21 Deg.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·5543692	548	0·4456708	9·9701317	81	0·0298483	9·5841774	629	10·4158226	60
1	[illegible]	548	0·4453419	9·9701032	81	0·0298968	9·5845549	629	10·4154451	59
2	9·5549869	547	0·4450132	9·9700547	81	0·0299453	9·5849321	628	10·4150679	58
3	9·5553152	547	[illegible]	9·9700061	81	0·0299939	9·5853091	628	10·4146909	57
4	9·5556433	546	[illegible]	9·9699574	81	0·0300426	9·5856859	627	10·4143141	56
5	9·5559711	546	[illegible]	9·9699087	81	0·0300913	9·5860624	627	10·4139376	55
6	9·5562988	545	[illegible]	9·9698600	81	0·0301400	9·5864380	627	10·4135614	54
7	9·5566259	545	0·4433741	9·9698112	81	0·0301888	9·5868147	626	10·4131853	53
8	9·5569529	544	0·4430471	9·9697623	81	0·0302376	9·5871904	626	10·4128094	52
9	9·5572794	544	[illegible]	9·9697136	81	[illegible]	9·5875660	625	10·4124340	51
10	9·5576060	543	0·4423940	9·9696647	81	0·0303353	9·5879413	625	10·4120587	50
11	[illegible]	543	0·4420679	9·9696158	81	[illegible]	9·5883163	625	10·4116837	49
12	9·5582579	543	0·4417421	9·9695668	82	0·0304332	9·5886912	624	10·4113088	48
13	9·5585835	542	0·4414165	9·9695177	82	0·0304823	9·5890657	624	10·4109343	47
14	9·5589088	542	0·4410912	9·9694687	82	0·0305313	[illegible]	623	10·4105599	46
15	9·5592338	541	0·4407662	9·9694196	82	0·0305804	9·5898142	623	10·4101858	45
16	9·5595585	541	0·4404415	9·9693704	82	[illegible]	9·5901881	623	10·4098119	44
17	9·5598829	540	0·4401171	9·9693212	82	[illegible]	9·5905617	622	10·4094383	43
18	9·5602071	540	0·4397929	9·9692720	82	0·0307280	9·5909351	622	10·4090649	42
19	9·5605310	539	0·4394690	9·9692227	82	0·0307773	9·5913082	622	10·4086918	41
20	9·5608546	539	0·4391454	9·9691734	82	0·0308266	9·5916812	621	10·4083188	40
21	9·5611779	538	0·4388221	9·9691241	82	0·0308759	9·5920539	621	10·4079461	39
22	9·5615010	538	0·4384990	9·9690746	82	0·0309254	9·5924263	620	10·4075737	38
23	9·5618237	537	0·4381763	9·9690252	82	0·0309748	9·5927985	620	10·4072015	37
24	9·5621462	537	0·4378538	9·9689757	82	0·0310243	9·5931705	620	10·4068295	36
25	9·5624685	536	0·4375315	9·9689262	83	0·0310738	[illegible]	619	10·4064577	35
26	9·5627904	536	0·4372096	[illegible]	83	[illegible]	[illegible]	619	10·4060862	34
27	9·5631121	536	0·4368879	9·9688270	83	0·0311730	9·5942854	618	10·4057149	33
28	[illegible]	535	0·4365665	9·9687773	83	0·0312227	9·5946561	618	10·4053439	32
29	[illegible]	535	0·4362454	9·9687276	83	0·0312724	9·5950269	618	10·4049731	31
30	9·5640754	534	0·4359246	9·9686779	83	0·0313221	9·5953975	617	10·4046025	30
31	9·5643960	534	0·4356040	9·9686281	83	[illegible]	9·5957679	617	10·4042321	29
32	9·5647163	[illegible]	0·4352837	9·9685783	83	[illegible]	9·5961380	616	10·4038620	28
33	9·5650363	[illegible]	0·4349637	9·9685284	83	[illegible]	9·5965079	616	10·4034921	27
34	9·5653561	[illegible]	0·4346439	[illegible]	83	0·0315215	9·5968776	616	10·4031224	26
35	9·5656756	532	0·4343244	9·9684286	83	0·0315714	9·5972470	615	10·4027530	25
36	9·5659948	532	0·4340052	9·9683786	83	0·0316214	9·5976162	615	10·4023838	24
37	9·5663137	531	0·4336863	9·9683285	83	0·0316715	9·5979852	615	10·4020148	23
38	9·5666324	531	0·4333676	9·9682784	83	0·0317216	9·5983540	614	10·4016460	22
39	9·5669508	530	0·4330492	9·9682283	84	0·0317717	9·5987225	614	10·4012775	21
40	9·5672689	530	[illegible]	9·9681781	84	0·0318219	9·5990908	613	10·4009092	20
41	9·5675868	529	[illegible]	9·9681279	84	0·0318721	9·5994588	613	10·4005412	19
42	9·5679044	529	0·4320956	9·9680777	84	0·0319223	9·5998267	613	10·4001733	18
43	9·5682217	528	0·4317783	9·9680274	84	0·0319726	9·6001943	612	10·3998057	17
44	[illegible]	528	0·4314613	9·9679771	84	0·0320229	9·6005617	612	10·3994383	16
45	[illegible]	528	0·4311445	9·9679267	84	0·032073	9·6009289	611	10·3990711	15
46	[illegible]	527	0·4308279	9·9678763	84	0·0321237	9·6012958	611	10·3987042	14
47	[illegible]	527	0·4305117	9·9678258	84	0·0321742	9·6016625	[illegible]	10·3983375	13
48	[illegible]	526	0·4301957	9·9677753	84	0·0322247	9·6020290	[illegible]	10·3979710	12
49	9·5701200	526	0·4298800	9·9677247	84	0·0322753	9·6023953	[illegible]	10·3976047	11
50	9·5704355	525	0·4295645	9·9676741	84	0·0323259	9·6027613	610	10·3972387	10
51	9·5707506	525	0·4292494	9·9676235	84	0·0323765	9·6031271	609	10·3968729	9
52	9·5710656	524	[illegible]	9·9675728	84	0·0324272	9·6034927	609	10·3965073	8
53	9·5713802	524	[illegible]	9·9675221	85	0·0324779	9·6038581	609	10·3961419	7
54	[illegible]	523	[illegible]	9·9674713	85	0·0325287	9·6042233	608	10·3957767	6
55	9·5720087	523	[illegible]	9·9674205	85	0·0325795	9·6045882	608	10·3954118	5
56	9·5723226	523	0·4276774	9·9673697	85	0·0326303	9·6049529	607	10·3950471	4
57	9·5526362	522	0·4273638	9·9673188	85	0·0326812	9·6053174	607	10·3946826	3
58	9·5729495	522	0·4270505	9·9672679	85	0·0327321	9·6056817	607	10·3943183	2
59	[illegible]	521	0·4267374	[illegible]	85	0·0327831	9·6060457	606	10·3939543	1
60	[illegible]		0·4264246	9·9671659	85	0·0328341	9·6064096		10·3935904	0
	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp. sin	Cosine	D10″	Comp. cos	Tangent	D10″	Cotangent	′
0	9·5735754	521	0·4264246	9·9671659	85	0·0328341	9·6064096	606	10·3935904	60
1	9·5738880	520	0·4261120	9·9671148	85	0·0328852	9·6067732	[illegible]	10·3932268	59
2	9·5742003	520	0·4257997	9·9670637	85	0·0329363	9·6071366	[illegible]	10·3928634	58
3	9·5745123	519	0·4254877	9·9670125	85	0·0329875	9·6074998	605	10·3925002	57
4	9·5748240	519	0·4251760	9·9669614	85	0·0330386	9·6078626	604	10·3921374	56
5	9·5751356	519	0·4248644	9·9669101	85	0·0330899	9·6082255	604	10·3917745	55
6	9·5754468	518	0·4245532	9·9668589	85	0·0331411	9·6085880	604	10·3914120	54
7	9·5757578	518	0·4242422	9·9668075	85	0·0331925	9·6089503	603	10·3910497	53
8	9·5760685	517	0·4239315	9·9667562	86	0·0332438	9·6093124	603	10·3906876	52
9	9·5763790	517	0·4236210	9·9667048	86	0·0332952	9·6096742	603	10·3903258	51
10	9·5766892	516	0·4233108	9·9666533	[illegible]	0·0333467	9·6100359	602	10·3899641	50
11	9·5769991	516	0·4230009	9·9666018	[illegible]	0·0333982	9·6103973	602	10·3896027	49
12	9·5773088	516	0·4226912	9·9665503	[illegible]	0·0334497	9·6107586	602	10·3892414	48
13	9·5776183	515	0·4223817	9·9664987	86	0·0335013	9·6111196	601	10·3888804	47
14	9·5779275	515	0·4220725	9·9664471	86	0·0335529	9·6114804	601	10·3885196	46
15	9·5782364	514	0·4217636	9·9663954	86	0·0336046	9·6118409	601	10·3881591	45
16	9·5785450	514	0·4214550	9·9663437	86	0·0336563	9·6122013	600	10·3877987	44
17	9·5788535	513	0·4211465	9·9662920	86	0·0337080	9·6125615	600	10·3874385	43
18	9·5791616	513	0·4208384	9·9662402	86	0·0337598	9·6129214	600	10·3870786	42
19	9·5794695	513	0·4205305	9·9661884	86	0·0338116	9·6132812	599	10·3867188	41
20	9·5797772	512	0·4202228	9·9661365	86	0·0338635	9·6136407	599	10·3863593	40
21	9·5800845	512	0·4199155	9·9660846	87	0·0339154	9·6140000	598	10·3860000	39
22	9·5803917	511	0·4196083	9·9660326	87	0·0339674	9·6143591	598	10·3856409	38
23	9·5806986	511	0·4193014	9·9659806	87	0·0340194	9·6147180	598	10·3852820	37
24	9·5810052	511	0·4189948	9·9659285	87	0·0340715	9·6150766	597	10·3849234	36
25	9·5813116	510	0·4186884	9·9658764	87	0·0341236	9·6154351	597	10·3845649	35
26	9·5816177	510	0·4183823	9·9658243	87	0·0341757	9·6157934	597	10·3842066	34
27	9·5819236	509	0·4180764	9·9657721	87	0·0342279	9·6161514	596	10·3838486	33
28	9·5822292	509	0·4177708	9·9657199	87	0·0342801	9·6165093	596	10·3834907	32
29	9·5825345	509	0·4174655	9·9656677	87	0·0343323	9·6168669	596	10·3831331	31
30	9·5828397	508	0·4171603	9·9656153	87	0·0343847	9·6172243	595	10·3827757	30
31	9·5831445	508	0·4168555	9·9655630	87	0·0344370	9·6175815	595	10·3824185	29
32	9·5834491	507	0·4165509	9·9655106	87	0·0344894	9·6179385	[illegible]	10·3820615	28
33	9·5837535	507	0·4162465	9·9654582	87	0·0345418	9·6182953	[illegible]	10·3817047	27
34	9·5840576	506	0·4159424	9·9654057	87	0·0345943	9·6186519	[illegible]	10·3813481	26
35	9·5843615	506	0·4156385	9·9653532	88	0·0346468	9·6190083	594	10·3809917	25
36	9·5846651	506	0·4153349	9·9653006	88	0·0346994	9·6193645	593	10·3806355	24
37	9·5849685	505	0·4150315	9·9652480	88	0·0347520	9·6197205	593	10·3802795	23
38	9·5852716	505	0·4147284	9·9651953	88	0·0348047	9·6200762	593	10·3799238	22
39	9·5855745	504	0·4144255	9·9651426	88	0·0348574	9·6204318	592	10·3795682	21
40	9·5858771	504	0·4141229	9·9650899	88	0·0349101	9·6207872	[illegible]	10·3792128	20
41	9·5861795	503	0·4138205	9·9650371	86	0·0349629	9·6211423	[illegible]	10·3788577	19
42	9·5864816	503	0·4135184	9·9649843	88	0·0350157	9·6214973	591	10·3785027	18
43	9·5867835	503	0·4132165	9·9649314	88	0·0350686	9·6218520	591	10·3781480	17
44	9·5870851	502	0·4129149	9·9648785	88	0·0351215	9·6222066	590	10·3777934	16
45	9·5873865	502	0·4126135	9·9648256	88	0·0351744	9·6225609	[illegible]	10·3774391	15
46	9·5876876	501	0·4123124	9·9647726	88	0·0352274	9·6229150	[illegible]	10·3770850	14
47	9·5879885	501	0·4120115	9·9647195	88	0·0352805	9·6232690	[illegible]	10·3767310	13
48	9·5882892	[illegible]	0·4117108	9·9646665	89	0·0353335	9·6236227	589	10·3763773	12
49	9·5885896	500	0·4114104	9·9646133	89	0·0353867	9·6239763	589	10·3760237	11
50	9·5888897	500	0·4111103	9·9645602	89	0·0354398	9·6243296	588	10·3756704	10
51	9·5891897	499	0·4108103	9·9645069	89	0·0354931	9·6246827	588	10·3753173	9
52	9·5894893	499	0·4105107	9·9644537	89	0·0355463	9·6250356	588	10·3749644	8
53	9·5897888	499	0·4102112	9·9644004	89	0·0355996	9·6253884	587	10·3746116	7
54	9·5900880	498	0·4099120	9·9643470	89	0·0356530	9·6257409	587	10·3742591	6
55	9·5903869	498	0·4096131	9·9642937	89	0·0357063	9·6260932	587	10·3739068	5
56	9·5906856	497	0·4093144	9·9642402	89	0·0357598	9·6264454	586	10·3735546	4
57	9·5909841	497	0·4090159	9·9641868	89	0·0358132	9·6267973	586	10·3732027	3
58	9·5912823	497	0·4087177	9·9641332	89	0·0358668	9·6271491	586	10·3728509	2
59	9·5915803	496	0·4084197	9·9640797	89	0·0359203	9·6275006	585	10·3724994	1
60	9·5918780		0·4081220	9·9640261		0·0359739	9·6278519		10·3721481	0
′	Cosine	D10″	Comp. cos	Sine	D10″	Comp. sin	Cotang.	D10″	Tangent	′

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′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·5918780	496	0·4081220	9·9640261	89	0·0359739	9·6278519	585	10·3721481	60
1	9·5921755	495	0·4078245	9·9639724	89	0·0360276	9·6282031	585	10·3717969	59
2	9·5924728	495	0·4075272	9·9639187	89	0·0360813	9·6285540	585	10·3714460	58
3	9·5927698	495	0·4072302	9·9638650	90	0·0361350	9·6289048	584	10·3710952	57
4	9·5930666	494	0·4069334	9·9638112	90	0·0361888	9·6292553	584	10·3707447	56
5	9·5933631	494	0·4066369	9·9637574	90	0·0362426	9·6296057	584	10·3703943	55
6	9·5936594	493	0·4063406	9·9637036	90	0·0362964	9·6299558	583	10·3700442	54
7	9·5939555	493	0·4060445	9·9636496	90	0·0363504	9·6303058	583	10·3696942	53
8	9·5942513	493	0·4057487	9·9635957	90	0·0364043	9·6306556	583	10·3693444	52
9	9·5945469	492	0·4054531	9·9635417	90	0·0364583	9·6310052	582	10·3689948	51
10	9·5948422	492	0·4051578	9·9634877	90	0·0365123	9·6313545	582	10·3686455	50
11	9·5951373	491	0·4048627	9·9634336	90	0·0365664	9·6317037	582	10·3682963	49
12	9·5954322	491	0·4045678	9·9633795	90	0·0366205	9·6320527	581	10·3679473	48
13	9·5957268	491	0·4042732	9·9633253	90	0·0366747	9·6324015	581	10·3675985	47
14	9·5960212	490	0·4039788	9·9632711	90	0·0367289	9·6327501	581	10·3672499	46
15	9·5963154	490	0·4036846	9·9632169	90	0·0367831	9·6330985	580	10·3669015	45
16	9·5966093	489	0·4033907	9·9631625	90	0·0368375	9·6334468	580	10·3665532	44
17	9·5969030	489	0·4030970	9·9631082	91	0·0368918	9·6337948	580	10·3662052	43
18	9·5971965	489	0·4028035	9·9630539	91	0·0369461	9·6341426	579	10·3658574	42
19	9·5974897	488	0·4025103	9·9629994	91	0·0370006	9·6344903	579	10·3655097	41
20	9·5977827	488	0·4022173	9·9629449	91	0·0370551	9·6348378	579	10·3651622	40
21	9·5980754	487	0·4019246	9·9628904	91	0·0371096	9·6351850	578	10·3648150	39
22	9·5983679	487	0·4016321	9·9628358	91	0·0371642	9·6355321	578	10·3644679	38
23	9·5986602	487	0·4013398	9·9627812	91	0·0372188	9·6358790	578	10·3641210	37
24	9·5989523	486	0·4010477	9·9627266	91	0·0372734	9·6362257	577	10·3637743	36
25	9·5992441	486	0·4007559	9·9626719	91	0·0373281	9·6365722	577	10·3634278	35
26	9·5995357	485	0·4004643	9·9626172	91	0·0373828	9·6369185	577	10·3630815	34
27	9·5998270	485	0·4001730	9·9625624	91	0·0374376	9·6372646	577	10·3627354	33
28	9·6001181	485	0·3998819	9·9625076	91	0·0374924	9·6376106	576	10·3623894	32
29	9·6004090	484	0·3995910	9·9624527	91	0·0375473	9·6379563	576	10·3620437	31
30	9·6006997	484	0·3993003	9·9623978	92	0·0376022	9·6383019	576	10·3616981	30
31	9·6009901	484	0·3990099	9·9623428	92	0·0376572	9·6386473	575	10·3613527	29
32	9·6012803	483	0·3987197	9·9622878	92	0·0377122	9·6389925	575	10·3610075	28
33	9·6015703	483	0·3984297	9·9622328	92	0·0377672	9·6393375	575	10·3606625	27
34	9·6018600	482	0·3981400	9·9621777	92	0·0378223	9·6396823	574	10·3603177	26
35	9·6021495	482	0·3978505	9·9621226	92	0·0378774	9·6400269	574	10·3599731	25
36	9·6024388	482	0·3975612	9·9620674	92	0·0379326	9·6403714	574	10·3596286	24
37	9·6027278	481	0·3972722	9·9620122	92	0·0379878	9·6407156	573	10·3592844	23
38	9·6030166	481	0·3969834	9·9619569	92	0·0380431	9·6410597	573	10·3589403	22
39	9·6033052	481	0·3966948	9·9619016	92	0·0380984	9·6414036	573	10·3585964	21
40	9·6035936	480	0·3964064	9·9618463	92	0·0381537	9·6417475	573	10·3582527	20
41	9·6038817	480	0·3961183	9·9617909	92	0·0382091	9·6420908	572	10·3579092	19
42	9·6041696	479	0·3958304	9·9617355	92	0·0382645	9·6424342	572	10·3575658	18
43	9·6044573	479	0·3955427	9·9616800	92	0·0383200	9·6427773	572	10·3572227	17
44	9·6047448	479	0·3952552	9·9616245	93	0·0383755	9·6431203	571	10·3568797	16
45	9·6050320	478	0·3949680	9·9615689	93	0·0384311	9·6434631	571	10·3565369	15
46	9·6053190	478	0·3946810	9·9615133	93	0·0384867	9·6438057	571	10·3561943	14
47	9·6056058	478	0·3943942	9·9614576	93	0·0385424	9·6441481	570	10·3558519	13
48	9·6058923	477	0·3941077	9·9614020	93	0·0385980	9·6444903	570	10·3555097	12
49	9·6061786	477	0·3938214	9·9613462	93	0·0386538	9·6448324	570	10·3551676	11
50	9·6064647	476	0·3935353	9·9612904	93	0·0387096	9·6451743	569	10·3548257	10
51	9·6067506	476	0·3932494	9·9612346	93	0·0387654	9·6455160	569	10·3544840	9
52	9·6070362	476	0·3929638	9·9611787	93	0·0388213	9·6458575	569	10·3541425	8
53	9·6073216	475	0·3926784	9·9611228	93	0·0388772	9·6461988	569	10·3538012	7
54	9·6076068	475	0·3923932	9·9610668	93	0·0389332	9·6465400	568	10·3534600	6
55	9·6078918	474	0·3921082	9·9610108	93	0·0389892	9·6468810	568	10·3531190	5
56	9·6081765	474	0·3918235	9·9609548	93	0·0390452	9·6472217	568	10·3527783	4
57	9·6084611	474	0·3915389	9·9608987	93	0·0391013	9·6475624	567	10·3524376	3
58	9·6087454	473	0·3912546	9·9608426	94	0·0391574	9·6479028	567	10·3520972	2
59	9·6090294	473	0·3909706	9·9607864	94	0·0392136	9·6482431	567	10·3517569	1
60	9·6093133		0·3906867	9·9607302		0·0392698	9·6485831		10·3514169	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

Tab. 18. Deg. 66.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·6093133	473	0·3906867	9·9607302	94	0·0392698	9·6485831	566	10·3514169	60
1	9·6095969	472	0·3904031	9·9606739	94	0·0393261	9·6489230	566	10·3510770	59
2	9·6098803	472	0·3901197	9·9606176	94	0·0393824	9·6492628	566	10·3507372	58
3	9·6101635	472	0·3898365	9·9605612	94	0·0394388	9·6496023	566	10·3503977	57
4	9·6104465	471	0·3895535	9·9605048	94	0·0394952	9·6499417	565	10·3500583	56
5	9·6107293	471	0·3892707	9·9604484	94	0·0395516	9·6502809	565	10·3497191	55
6	9·6110118	470	0·3889882	9·9603919	94	0·0396081	9·6506199	565	10·3493801	54
7	9·6112941	470	0·3887059	9·9603354	94	0·0396646	9·6509587	564	10·3490413	53
8	9·6115762	470	0·3884238	9·9602788	94	0·0397212	9·6512974	564	10·3487026	52
9	9·6118580	469	0·3881420	9·9602222	94	0·0397778	9·6516359	564	10·3483641	51
10	9·6121397	469	0·3878603	9·9601655	94	0·0398345	9·6519742	563	10·3480258	50
11	9·6124211	469	0·3875789	9·9601088	95	0·0398912	9·6523123	563	10·3476877	49
12	9·6127023	468	0·3872977	9·9600520	95	0·0399480	9·6526503	563	10·3473497	48
13	9·6129833	468	0·3870167	9·9599952	95	0·0400048	9·6529881	563	10·3470119	47
14	9·6132641	467	0·3867359	9·9599384	95	0·0400616	9·6533257	562	10·3466743	46
15	9·6135446	467	0·3864554	9·9598815	95	0·0401185	9·6536631	562	10·3463369	45
16	9·6138250	467	0·3861750	9·9598246	95	0·0401754	9·6540004	562	10·3459996	44
17	9·6141051	466	0·3858949	9·9597676	95	0·0402324	9·6543375	561	10·3456625	43
18	9·6143850	466	0·3856150	9·9597106	95	0·0402894	9·6546744	561	10·3453256	42
19	9·6146647	466	0·3853353	9·9596535	95	0·0403465	9·6550112	561	10·3449888	41
20	9·6149441	465	0·3850559	9·9595964	95	0·0404036	9·6553477	561	10·3446523	40
21	9·6152234	465	0·3847766	9·9595393	95	0·0404607	9·6556841	560	10·3443159	39
22	9·6155024	465	0·3844976	9·9594821	95	0·0405179	9·6560204	560	10·3439796	38
23	9·6157812	464	0·3842188	9·9594248	95	0·0405752	9·6563564	560	10·3436436	37
24	9·6160599	464	0·3839401	9·9593675	96	0·0406325	9·6566923	559	10·3433077	36
25	9·6163383	464	0·3836617	9·9593102	96	0·0406898	9·6570280	559	10·3429720	35
26	9·6166164	463	0·3833836	9·9592528	96	0·0407472	9·6573636	559	10·3426364	34
27	9·6168944	463	0·3831056	9·9591954	96	0·0408046	9·6576989	559	10·3423011	33
28	9·6171721	462	0·3828279	9·9591380	96	0·0408620	9·6580341	558	10·3419659	32
29	9·6174496	462	0·3825504	9·9590805	96	0·0409195	9·6583692	558	10·3416308	31
30	9·6177270	462	0·3822730	9·9590229	96	0·0409771	9·6587041	558	10·3412959	30
31	9·6180041	461	0·3819959	9·9589653	96	0·0410347	9·6590387	558	10·3409613	29
32	9·6182809	461	0·3817191	9·9589077	96	0·0410923	9·6593733	557	10·3406267	28
33	9·6185576	461	0·3814424	9·9588500	96	0·0411500	9·6597076	557	10·3402924	27
34	9·6188341	460	0·3811659	9·9587923	96	0·0412077	9·6600418	557	10·3399582	26
35	9·6191103	460	0·3808897	9·9587345	96	0·0412655	9·6603758	556	10·3396242	25
36	9·6193864	460	0·3806136	9·9586767	96	0·0413233	9·6607097	556	10·3392903	24
37	9·6196622	459	0·3803378	9·9586188	96	0·0413812	9·6610434	556	10·3389566	23
38	9·6199378	459	0·3800622	9·9585609	96	0·0414391	9·6613769	556	10·3386231	22
39	9·6202132	459	0·3797868	9·9585030	97	0·0414970	9·6617103	555	10·3382897	21
40	9·6204884	458	0·3795116	9·9584450	97	0·0415550	9·6620434	555	10·3379566	20
41	9·6207634	458	0·3792366	9·9583869	97	0·0416131	9·6623765	555	10·3376235	19
42	9·6210382	458	0·3789618	9·9583288	97	0·0416712	9·6627093	554	10·3372907	18
43	9·6213127	457	0·3786873	9·9582707	97	0·0417293	9·6630420	554	10·3369580	17
44	9·6215871	457	0·3784129	9·9582125	97	0·0417875	9·6633746	554	10·3366254	16
45	9·6218612	457	0·3781388	9·9581546	97	0·0418457	9·6637069	554	10·3362931	15
46	9·6221351	456	0·3778649	9·9580961	97	0·0419039	9·6640391	553	10·3359609	14
47	9·6224088	456	0·3775912	9·9580378	97	0·0419622	9·6643711	553	10·3356289	13
48	9·6226824	455	0·3773176	9·9579794	97	0·0420206	9·6647030	553	10·3352970	12
49	9·6229557	455	0·3770443	9·9579210	97	0·0420790	9·6650346	553	10·3349654	11
50	9·6232287	455	0·3767713	9·9578626	97	0·0421374	9·6653662	552	10·3346338	10
51	9·6235016	454	0·3764984	9·9578041	97	0·0421959	9·6656973	552	10·3343025	9
52	9·6237743	454	0·3762257	9·9577456	98	0·0422544	9·6660288	552	10·3339712	8
53	9·6240468	454	0·3759532	9·9576870	98	0·0423130	9·6663598	551	10·3336402	7
54	9·6243190	453	0·3756810	9·9576284	98	0·0423716	9·6666907	551	10·3333093	6
55	9·6245911	453	0·3754089	9·9575697	98	0·0424303	9·6670214	551	10·3329786	5
56	9·6248629	453	0·3751371	9·9575110	98	0·0424890	9·6673519	551	10·3326481	4
57	9·6251346	452	0·3748654	9·9574522	98	0·0425478	9·6676822	550	10·3323177	3
58	9·6254060	452	0·3745940	9·9573934	98	0·0426066	9·6680126	550	10·3319874	2
59	9·6256772	452	0·3743228	9·9573346	98	0·0426654	9·6683426	550	10·3316574	1
60	9·6259483		0·3740517	9·9572757		0·0427243	9·6686725		10·3313275	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotangent	D10″	Tangent	′

25 Deg. Tab. 18.

′	Sine	D. 10″	Comp. sin	Cosine	D. 10″	Comp. cos.	Tangent	D. 10″	Cotangent	′
0	9·6259483	452	[illegible]	9·9572757	[illegible]	0·0427243	9·6686725	550	10·3313275	60
1	9·6262194	451	[illegible]	9·9572168	[illegible]	0·0427832	9·6690023	549	10·3309977	59
2	9·6264897	451	0·3735103	[illegible]	98	0·0428422	9·6693319	549	10·3306681	58
3	9·6267601	450	0·3732399	9·9570988	98	0·0429012	9·6696613	549	10·3303387	57
4	9·6270302	450	[illegible]	9·9570397	98	0·0429603	9·6699906	548	10·3300094	56
5	9·6273003	450	[illegible]	[illegible]	98	0·0430194	9·6703197	548	10·3296803	55
6	9·6275701	449	0·3724299	9·9569215	99	0·0430785	9·6706486	548	10·3293514	54
7	9·6278397	449	0·3721603	9·9568623	99	0·0431377	9·6709774	548	10·3290226	53
8	9·6281090	449	0·3718910	9·9568030	99	0·0431970	9·6713060	547	10·3286940	52
9	9·6283782	448	0·3716218	9·9567437	99	0·0432563	9·6716345	547	10·3283655	51
10	9·6286472	448	0·3713528	9·9566844	99	0·0433156	9·6719628	547	10·3280372	50
11	9·6289160	448	0·3710840	9·9566250	99	0·0433750	9·6722910	547	10·3277090	49
12	9·6291845	447	0·3708155	9·9565656	99	0·0434344	9·6726190	546	10·3273810	48
13	9·6294529	447	0·3705471	9·9565061	99	0·0434939	9·6729468	546	10·3270532	47
14	9·6297211	447	0·3702789	9·9564466	99	0·0435534	9·6732745	546	10·3267255	46
15	9·6299890	446	0·3700110	9·9563870	99	0·0436130	9·6736020	546	10·3263980	45
16	9·6302568	446	0·3697432	9·9563274	99	0·0436726	9·6739294	545	10·3260706	44
17	9·6305243	445	0·3694757	9·9562678	99	0·0437322	9·6742566	545	10·3257434	43
18	9·6307917	445	0·3692083	9·9562081	99	0·0437919	9·6745836	545	10·3254164	42
19	9·6310589	445	0·3689411	9·9561485	100	0·0438547	9·6749105	544	10·3250895	41
20	9·6313258	445	0·3686742	9·9560886	100	0·0439114	9·6752372	544	10·3247628	40
21	9·6315926	444	0·3684074	9·9560287	100	0·0439713	9·6755638	544	10·3244362	39
22	9·6318591	444	0·3681409	9·9559689	100	0·0440311	9·6758903	544	10·3241097	38
23	9·6321255	444	0·3678745	9·9559089	100	0·0440911	9·6762165	543	10·3237835	37
24	9·6323916	443	0·3676084	9·9558490	100	0·0441510	9·6765426	543	10·3234574	36
25	9·6326576	443	0·3673424	9·9557890	100	0·0442110	9·6768686	543	10·3231314	35
26	9·6329233	443	0·3670767	9·9557289	100	0·0442711	9·6771944	543	10·3228056	34
27	9·6331889	442	0·3668111	9·9556688	100	0·0443312	9·6775201	542	10·3224799	33
28	9·6334542	442	0·3665458	9·9556087	100	0·0443913	9·6778456	542	10·3221544	32
29	9·6337194	442	0·3662806	9·9555485	100	0·0444515	9·6781709	542	10·3218291	31
30	9·6339844	441	0·3660156	9·9554882	100	0·0445118	9·6784961	542	10·3215039	30
31	9·6342491	441	0·3657509	9·9554280	100	0·0445720	9·6788211	541	10·3211789	29
32	9·6345137	441	0·3654863	9·9553676	101	0·0446324	9·6791460	541	10·3208540	28
33	9·6347780	440	0·3652220	9·9553073	101	0·0446927	9·6794708	541	10 3205292	27
34	9·6350422	440	0·3649578	9·9552469	101	0·0447531	9·6797953	541	10·3202047	26
35	9·6353062	440	0·3646938	9·9551864	101	0·0448136	9·6801198	540	10·3198802	25
36	9·6355699	439	0·3644301	9·9551259	101	0·0448741	9·6804440	540	10·3195560	24
37	9·6358335	439	0·3641665	9·9550653	101	0·0449347	9·6807682	540	10·3192318	23
38	9·6360969	439	0·3639031	9·9550047	101	0·0449953	9·6810921	540	10·3189079	22
39	9·6363601	438	0·3636399	9·9549441	101	0·0450559	9·6814160	539	10·3185840	21
40	9·6366231	438	0·3633769	9·9548834	101	0·0451166	9·6817396	539	10·3182604	20
41	9·6368859	438	0·3631141	9·9548227	101	0·0451773	9·6820632	539	10·3179368	19
42	9·6371484	437	0·3628516	9·9547619	101	0 0452381	9·6823865	539	10·3176135	18
43	9·6374108	437	0·3625892	9·9547011	101	0·045298	9·6827098	538	10·3172902	17
44	9·6376731	437	0·3623269	9·9546402	101	0·0453598	9·6830328	538	10·3169672	16
45	9·6379351	436	0·3620649	9·9545793	101	0·0454207	9·6833557	538	10·3166443	15
46	9·6381969	436	0·3618031	9·9545184	102	0·0454816	9·6836785	538	10·3163215	14
47	9·6384585	436	0·3615415	9·9544574	102	0·0455426	9·6840011	537	10·3159989	13
48	9·6387199	435	0·3612801	9·9543963	102	0·0456037	9·6843236	537	10·3156764	12
49	9·6389812	435	0·3610188	9·9543352	102	0·0456648	9·6846459	537	10·3153541	11
50	9·6392422	435	0·3607578	9·9542741	102	0·0457259	9·6849681	537	10·3150319	10
51	9·6395030	434	0·3604970	9·9542129	102	0·0457871	9·6852901	536	10·3147099	9
52	9·6397637	434	0·3602363	9·9541517	102	0·0458483	9·6856120	536	10·3143880	8
53	9·6400241	434	0·3599759	9·9540904	102	0·0459096	9·6859338	536	10·3140662	7
54	9·6402844	434	0·3597156	9·9540291	102	0·0459709	9·6862553	536	10·3137447	6
55	9·6405445	433	0·3594555	9·9539677	102	0·0460323	9·6865768	535	10·3134232	5
56	9·6408044	433	0·3591956	9·9539063	102	0·0460937	9·6868981	535	10·3131019	4
57	9·6410640	433	0·3589360	9·9538448	102	0·0461552	9·6872192	535	10·3127808	3
58	9·6413235	432	0·3586765	9·9537833	102	0·0462167	9·6875402	535	10·3124598	2
59	9·6415828	432	0·3584172	9·9537218	103	0·0462782	9·6878611	534	10·3121389	1
60	9·6418420		0 3581580	9·9536602		0·0463398	9·6881818		10·3118182	0
′	Cosine	D. 10″	Comp. cos.	Sine	D. 10″	Comp. sin	Cotangent	D. 10″	Tangent	′

26 Deg. Tab. 18.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	[illegible]	431	0·3581580	9·9536602	103	[illegible]	[illegible]	534	[illegible]	60
1	9·6421009	431	[illegible]	9·9535985	[illegible]	[illegible]	[illegible]	534	[illegible]	59
2	9·6423596	431	[illegible]	9·9535369	[illegible]	[illegible]	[illegible]	534	[illegible]	58
3	9·6426182	430	[illegible]	9·9534751	103	[illegible]	[illegible]	533	[illegible]	57
4	9·6428765	430	[illegible]	9·9534134	103	0·0465866	[illegible]	533	[illegible]	56
5	[illegible]	430	[illegible]	9·9533516	103	[illegible]	[illegible]	533	[illegible]	55
6	9·6433926	430	0·3566074	9·9532897	103	[illegible]	[illegible]	533	[illegible]	54
7	9·6436504	429	0·3563496	9·9532278	103	[illegible]	9·6904226	533	[illegible]	53
8	9·6439080	429	0·3560920	[illegible]	103	0·0468342	9·6907422	532	[illegible]	52
9	9·6441654	429	0·3558346	[illegible]	[illegible]	0·0468962	9·6910616	532	10·3089384	51
10	9·6444226	428	0·3555774	[illegible]	[illegible]	0·0469582	[illegible]	532	10·3086191	50
11	9·6446796	428	0·3553204	[illegible]	104	0·0470203	9·6917000	532	[illegible]	49
12	9·6449365	428	0·3550635	[illegible]	104	0·0470825	9·6920189	531	[illegible]	48
13	9·6451931	427	0·3548069	[illegible]	104	0·0471447	9·6923378	531	10·3076622	47
14	9·6454496	427	0·3545504	[illegible]	104	0·0472069	9·6926565	531	10·3073435	46
15	9·6457058	427	0·3542942	[illegible]	104	0·0472692	9·6929750	531	10·3070250	45
16	9·6459619	426	0·3540381	9·9526685	104	0·0473315	[illegible]	530	[illegible]	44
17	9·6462178	426	[illegible]	9·9526061	104	0·0473939	9·6936117	530	[illegible]	43
18	9·6464735	426	[illegible]	9·9525437	104	0·0474563	9·6939298	530	10·3060702	42
19	9·6467290	426	0·3532710	9·9524813	104	0·0475187	9·6942478	530	[illegible]	41
20	9·6469844	425	0·3530156	9·9524188	104	0·0475812	9·6945656	529	10·3054344	40
21	9·6472395	425	0·3527605	9·9523562	104	0·0476438	[illegible]	529	10·3051167	39
22	9·6474945	425	0·3525055	9·9522936	104	0·0477064	9·6952009	529	10·3047991	38
23	9·6477492	424	0·3522508	9·9522310	104	0·0477690	9·6955183	529	10·3044817	37
24	9·6480038	424	0·3519962	9·9521683	105	0·0478317	9·6958355	529	10·3041645	36
25	9·6482582	424	0·3517418	9·9521055	105	0·0478945	9·6961527	528	10·3038473	35
26	9·6485124	423	[illegible]	9·9520428	105	0·0479572	9·6964697	[illegible]	10·3035303	34
27	9·6487665	423	[illegible]	9·9519799	105	0·0480201	9·6967865	[illegible]	10·3032135	33
28	9·6490208	423	[illegible]	9·9519171	105	0·0480829	9·6971032	526	10·3028968	32
29	9·6492740	422	0·3507260	9·9518541	105	0·0481459	9·6974198	527	10·3025802	31
30	9·6495274	422	0·3504726	9·9517912	105	0·0482088	9·6977363	527	10·3022637	30
31	9·6497807	422	0·3502193	9·9517282	105	0·0482718	9·6980526	527	10·3019474	29
32	9·6500338	422	0·3499662	9·9516651	105	0·0483349	[illegible]	527	10·3016313	28
33	9·6502868	421	[illegible]	9·9516020	105	0·0483980	[illegible]	526	[illegible]	27
34	9·6505395	421	0·3494605	9·9515389	105	[illegible]	[illegible]	526	[illegible]	26
35	9·6507920	421	0·3492080	9·9514757	105	0·0485243	[illegible]	526	10·3006836	25
36	9·6510444	420	0·3489556	9·9514124	[illegible]	0·0485876	[illegible]	526	10·3003680	24
37	9·6512966	420	[illegible]	[illegible]	106	0·0486508	9·6999474	526	10·3000526	23
38	9·6515486	420	0·3484514	9·9512855	106	0·0487142	[illegible]	525	[illegible]	22
39	9·6518004	419	0·3481996	9·9512224	106	0·0487776	9·7005780	525	10·2994220	21
40	9·6520521	419	0·3479479	9·9511590	106	0·0488410	9·7008930	525	10·2991070	20
41	9·6523035	419	[illegible]	9·9510956	106	0·0489044	9·7012080	525	10·2987920	19
42	9·6525545	418	0·3474452	9·9510320	106	0·0489680	9·7015227	524	10·2984773	18
43	9·6528059	418	0·3471941	9·9509685	106	0·0490315	9·7018374	524	10·2981626	17
44	9·6530568	418	0·3469432	9·9509049	106	0·0490951	9·7021519	524	10·2978481	16
45	9·6533075	418	0·3466925	9·9508412	106	0·0491588	9·7024663	[illegible]	10·2975337	15
46	9·6535581	417	0·3464419	9·9507775	106	0·0492225	9·7027805	[illegible]	10·2972195	14
47	9·6538084	417	0·3461916	9·9507138	106	0·0492862	9·7030946	[illegible]	10·2969054	13
48	[illegible]	417	0·3459413	9·9506500	106	0·0493500	[illegible]	[illegible]	[illegible]	12
49	[illegible]	416	0·3456914	9·9505861	106	0·0494139	9·7037225	523	10·2962775	11
50	9·6545584	416	0·3454416	9·9505223	107	0·0494777	9·7040362	522	10·2959638	10
51	9·6548081	416	0·3451919	9·9504583	107	0·0495417	9·7043499	522	10·2956503	9
52	9·6550575	415	0·3449425	9·9503944	107	0·0496056	9·7046632	522	10·2953368	8
53	9·6553068	415	0·3446932	9·9503303	107	[illegible]	9·7049765	522	10·2950235	7
54	9·6555559	415	0·3444441	9·9502663	107	[illegible]	[illegible]	522	10·2947103	6
55	9·6558048	[illegible]	0·3441952	9·9502022	107	0·0497978	[illegible]	521	10·2943973	5
56	9·6560536	414	0·3439464	9·9501380	107	0·0498620	[illegible]	521	10·2940844	4
57	9·6563021	414	0·3436979	9·9500738	107	[illegible]	9·7062284	521	10·2937716	3
58	9·6565505	414	0·3434495	9·9500095	107	[illegible]	9·7065410	521	[illegible]	2
59	9·6567987	413	0·3432013	9·9499452	[illegible]	0·0500548	9·7068535	521	[illegible]	1
60	9·6570468		0·3429532	9·9498809		0·0501191	9·7071659		10·2928341	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

Tab. 18. Deg. 63.

27 Deg. Tab. 18.

′	Sine.	D10″	Comp. sin.	Cosine.	D10″	Comp. cos.	Tangent.	D10″	Cotangent.	′
0	9·6570468	413	0·3429532	9·9498809	107	0·0501191	9·7071659	520	10·2928341	60
1	9·6572946	413	0·3427054	9·9498165	107	0·0501835	9·7074781	520	10·2925219	59
2	9·6575423	412	0·3424577	9·9497521	107	0·0502479	9·7077902	520	10·2922098	58
3	9·6577898	412	0·3422102	9·9496876	108	0·0503124	9·7081022	520	10·2918978	57
4	9·6580371	412	0·3419629	9·9496230	108	0·0503770	9·7084141	519	10·2915859	56
5	9·6582842	412	0·3417158	9·9495585	108	0·0504415	9·7087258	519	10·2912742	55
6	9·6585312	411	0·3414688	9·9494938	108	0·0505062	9·7090374	519	10·2909626	54
7	9·6587780	411	0·3412220	9·9494292	108	0·0505708	9·7093488	519	10·2906512	53
8	9·6590246	411	0·3409754	9·9493645	108	0·0506355	9·7096601	519	10·2903399	52
9	9·6592710	410	0·3407290	9·9492997	108	0·0507003	9·7099713	518	10·2900287	51
10	9·6595173	410	0·3404827	9·9492349	108	0·0507651	9·7102824	518	10·2897176	50
11	9·6597633	410	0·3402367	9·9491700	108	0·0508300	9·7105933	518	10·2894067	49
12	9·6600093	409	0·3399907	9·9491051	108	0·0508949	9·7109041	518	10·2890959	48
13	9·6602550	409	0·3397450	9·9490402	108	0·0509598	9·7112148	518	10·2887852	47
14	9·6605005	409	0·3394995	9·9489752	108	0·0510248	9·7115254	517	10·2884746	46
15	9·6607459	408	0·3392541	9·9489101	108	0·0510899	9·7118358	517	10·2881642	45
16	9·6609911	408	0·3390089	9·9488450	108	0·0511550	9·7121461	517	10·2878539	44
17	9·6612361	408	0·3387639	9·9487799	109	0·0512201	9·7124562	517	10·2875438	43
18	9·6614810	408	0·3385190	9·9487147	109	0·0512853	9·7127662	516	10·2872338	42
19	9·6617257	407	0·3382743	9·9486495	109	0·0513505	9·7130761	516	10·2869239	41
20	9·6619702	407	0·3380298	9·9485842	109	0·0514158	9·7133859	516	10·2866141	40
21	9·6622145	407	0·3377855	9·9485189	109	0·0514811	9·7136956	516	10·2863044	39
22	9·6624586	407	0·3375414	9·9484535	109	0·0515465	9·7140051	516	10·2859949	38
23	9·6627026	406	0·3372974	9·9483881	109	0·0516119	9·7143145	515	10·2856855	37
24	9·6629464	406	0·3370536	9·9483227	109	0·0516773	9·7146237	515	10·2853763	36
25	9·6631900	406	0·3368100	9·9482572	109	0·0517428	9·7149329	515	10·2850671	35
26	9·6634335	405	0·3365665	9·9481916	109	0·0518084	9·7152419	515	10·2847581	34
27	9·6636768	405	0·3363232	9·9481260	109	0·0518740	9·7155508	515	10·2844492	33
28	9·6639199	405	0·3360801	9·9480604	109	0·0519396	9·7158595	514	10·2841405	32
29	9·6641628	405	0·3358372	9·9479947	110	0·0520053	9·7161682	514	10·2838318	31
30	9·6644056	404	0·3355944	9·9479289	110	0·0520711	9·7164767	514	10·2835233	30
31	9·6646482	404	0·3353518	9·9478631	110	0·0521369	9·7167851	514	10·2832149	29
32	9·6648906	404	0·3351094	9·9477973	110	0·0522027	9·7170933	513	10·2829067	28
33	9·6651329	403	0·3348671	9·9477314	110	0·0522686	9·7174014	513	10·2825986	27
34	9·6653749	403	0·3346251	9·9476655	110	0·0523345	9·7177094	513	10·2822906	26
35	9·6656168	403	0·3343832	9·9475995	110	0·0524005	9·7180173	513	10·2819827	25
36	9·6658586	402	0·3341414	9·9475335	110	0·0524665	9·7183251	513	10·2816749	24
37	9·6661001	402	0·3338999	9·9474674	110	0·0525326	9·7186327	512	10·2813673	23
38	9·6663415	402	0·3336585	9·9474013	110	0·0525987	9·7189402	512	10·2810598	22
39	9·6665828	402	0·3334172	9·9473352	110	0·0526648	9·7192476	512	10·2807524	21
40	9·6668238	401	0·3331762	9·9472689	110	0·0527311	9·7195549	512	10·2804451	20
41	9·6670647	401	0·3329353	9·9472027	110	0·0527973	9·7198620	512	10·2801380	19
42	9·6673054	401	0·3326946	9·9471364	111	0·0528636	9·7201690	511	10·2798310	18
43	9·6675459	401	0·3324541	9·9470700	111	0·0529300	9·7204759	511	10·2795241	17
44	9·6677863	400	0·3322137	9·9470036	111	0·0529964	9·7207827	511	10·2792173	16
45	9·6680265	400	0·3319735	9·9469372	111	0·0530628	9·7210893	511	10·2789107	15
46	9·6682665	400	0·3317335	9·9468707	111	0·0531293	9·7213958	511	10·2786042	14
47	9·6685064	399	0·3314936	9·9468042	111	0·0531958	9·7217022	510	10·2782978	13
48	9·6687461	399	0·3312539	9·9467376	111	0·0532624	9·7220085	510	10·2779915	12
49	9·6689856	399	0·3310144	9·9466710	111	0·0533290	9·7223147	510	10·2776853	11
50	9·6692250	399	0·3307750	9·9466043	111	0·0533957	9·7226207	510	10·2773793	10
51	9·6694642	398	0·3305358	9·9465376	111	0·0534624	9·7229266	509	10·2770734	9
52	9·6697032	398	0·3302968	9·9464708	111	0·0535292	9·7232324	509	10·2767676	8
53	9·6699420	398	0·3300580	9·9464040	111	0·0535960	9·7235381	509	10·2764619	7
54	9·6701807	397	0·3298193	9·9463371	111	0·0536629	9·7238436	509	10·2761564	6
55	9·6704192	397	0·3295808	9·9462702	112	0·0537298	9·7241490	509	10·2758510	5
56	9·6706576	397	0·3293424	9·9462032	112	0·0537968	9·7244543	509	10·2755457	4
57	9·6708958	397	0·3291042	9·9461362	112	0·0538638	9·7247595	508	10·2752405	3
58	9·6711338	396	0·3288662	9·9460692	112	0·0539308	9·7250646	508	10·2749354	2
59	9·6713716	396	0·3286284	9·9460021	112	0·0539979	9·7253695	508	10·2746305	1
60	9·6716093		0·3283907	9·9459349		0·0540651	9·7256744		10·2743256	0
′	Cosine.	D10″	Comp. cos.	Sine.	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

Deg. 62.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·6716093	396	0·3283907	9·9459349	112	0·0540651	9·7256744	508	10·2743256	60
1	9·6718468	395	0·3281532	9·9458677	112	0·0541323	9·7259791	508	10·2740209	59
2	9·6720841	395	0·3279159	9·9458005	112	0·0541995	9·7262837	507	10·2737163	58
3	9·6723213	395	0·3276787	9·9457332	112	0·0542668	9·7265881	507	10·2734119	57
4	9·6725583	395	0·3274417	9·9456659	112	0·0543341	9·7268925	507	10·2731075	56
5	9·6727952	394	0·3272048	9·9455985	112	0·0544015	9·7271967	507	10·2728033	55
6	9·6730319	394	0·3269681	9·9455310	112	0·0544690	9·7275008	507	10·2724992	54
7	9·6732684	394	0·3267316	9·9454636	112	0·0545364	9·7278048	506	10·2721952	53
8	9·6735047	394	0·3264953	9·9453960	113	0·0546040	9·7281087	506	10·2718913	52
9	9·6737409	393	0·3262591	9·9453285	113	0·0546715	9·7284124	506	10·2715876	51
10	9·6739769	393	0·3260231	9·9452609	113	0·0547391	9·7287161	506	10·2712839	50
11	9·6742128	393	0·3257872	9·9451932	113	0·0548068	9·7290196	506	10·2709804	49
12	9·6744485	392	0·3255515	9·9451255	113	0·0548745	9·7293230	505	10·2706770	48
13	9·6746840	392	0·3253160	9·9450577	113	0·0549423	9·7296263	505	10·2703737	47
14	9·6749194	392	0·3250806	9·9449899	113	0·0550101	9·7299295	505	10·2700705	46
15	9·6751546	392	0·3248454	9·9449220	113	0·0550780	9·7302325	505	10·2697675	45
16	9·6753896	391	0·3246104	9·9448541	113	0·0551459	9·7305354	505	10·2694646	44
17	9·6756245	391	0·3243755	9·9447862	113	0·0552138	9·7308383	504	10·2691617	43
18	9·6758592	391	0·3241408	9·9447182	113	0·0552818	9·7311410	504	10·2688590	42
19	9·6760937	391	0·3239063	9·9446501	113	0·0553499	9·7314436	504	10·2685564	41
20	9·6763281	390	0·3236719	9·9445821	114	0·0554179	9·7317460	504	10·2682540	40
21	9·6765623	390	0·3234377	9·9445139	114	0·0554861	9·7320484	504	10·2679516	39
22	9·6767963	390	0·3232037	9·9444457	114	0·0555543	9·7323506	503	10·2676494	38
23	9·6770302	390	0·3229698	9·9443775	114	0·0556225	9·7326527	503	10·2673473	37
24	9·6772640	389	0·3227360	9·9443092	114	0·0556908	9·7326547	503	10·2670453	36
25	9·6774975	389	0·3225025	9·9442409	114	0·0557591	9·7332566	503	10·2667434	35
26	9·6777309	389	0·3222691	9·9441725	114	0·0558275	9·7335584	503	10·2664416	34
27	9·6779642	388	0·3220358	9·9441041	114	0·0558959	6·7338601	503	10·2661399	33
28	9·6781972	388	0·3218028	9·9440356	114	0·0559644	9·7341616	502	10·2658384	32
29	9·6784301	388	0·3215699	9·9439671	114	0·0560329	9·7344631	502	10·2655369	31
30	9·6786629	388	0·3213371	9·9438985	114	0·0561015	9·7347644	502	10·2652356	30
31	9·6788955	387	0·3211045	9·9438299	114	0·0561701	9·7350656	502	10·2649344	29
32	9·6791279	387	0·3208721	9·9437612	114	0·0562388	9·7353667	502	10·2646333	28
33	9·6793602	387	0·3206398	9·9436925	114	0·0563075	9·7356677	501	10·2643323	27
34	9·6795923	387	0·3204077	9·9436238	115	0·0563762	9·7359685	501	10·2640315	26
35	9·6798243	386	0·3201757	9·9435549	115	0·0564451	9·7362693	501	10·2637307	25
36	9·6800560	386	0·3199440	9·9434861	115	0·0565139	9·7365699	501	10·2634301	24
37	9·6802877	386	0·3197123	9·9434172	115	0·0565828	9·7368705	501	10·2631295	23
38	9·6805191	385	0·3194809	9·9433482	115	0·0566518	9·7371709	500	10·2628291	22
39	9·6807504	385	0·3192496	9·9432792	115	0·0567208	9·7374712	500	10·2625288	21
40	9·6809816	385	0·3190184	9·9432102	115	0·0567898	9·7377714	500	10·2622286	20
41	9·6812126	385	0·3187874	9·9431411	115	0·0568589	9·7380715	500	10·2619285	19
42	9·6814434	384	0·3185566	9·9430720	115	0·0569280	9·7383714	500	10·2616286	18
43	9·6816741	384	0·3183259	9·9430028	115	0·0569972	9·7386713	499	10·2613287	17
44	9·6819046	384	0·3180954	9·9429335	115	0·0570665	9·7389710	499	10·2610290	16
45	9·6821349	384	0·3178651	9·9428643	116	0·0571357	9·7392707	499	10·2607293	15
46	9·6823651	383	0·3176349	9·9427949	116	0·0572051	9·7395702	499	10·2604298	14
47	9·6825952	383	0·3174048	9·9427255	116	0·0572745	9·7398696	499	10·2601304	13
48	9·6828250	383	0·3171750	9·9426561	116	0·0573439	9·7401689	499	10·2598311	12
49	9·6830548	383	0·3169452	9·9425866	116	0·0574134	9·7404681	498	10·2595319	11
50	9·6832843	382	0·3167157	9·9425171	116	0·0574829	9·7407672	498	10·2592328	10
51	9·6835137	382	0·3164863	9·9424476	116	0·0575524	9·7410662	498	10·2589338	9
52	9·6837430	382	0·3162570	9·9423779	116	0·0576221	9·7413650	498	10·2586350	8
53	9·6839720	382	0·3160280	9·9423083	116	0·0576917	9·7416638	498	10·2583362	7
54	9·6842010	381	0·3157990	9·9422386	116	0·0577614	9·7419624	497	10·2580376	6
55	9·6844297	381	0·3155703	9·9421688	116	0·0578312	9·7422609	497	10·2577391	5
56	9·6846583	381	0·3153417	9·9420990	116	0·0579010	9·7425594	497	10·2574406	4
57	9·6848866	380	0·3151132	9·9420291	116	0·0579709	9·7428577	497	10·2571423	3
58	9·6851151	380	0·3148849	9·9419592	116	0·0580408	9·7431559	497	10·2568441	2
59	9·6853432	380	0·3146568	9·9418893	117	0·0581107	9·7434540	497	10·2565460	1
60	9·6855712		0·3144288	9·9418195		0·0581807	9·7437520		10·2562480	0
′	Cosine	D10″	Comp. co-	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

29 Deg.

′	Sine	D 10″	Comp. sin.	Cosine	D 10″	Comp. cos.	Tangent	D 10″	Cotangent	′
0	9·6855712	380	0·3144288	9·9418193	117	0·0581807	9·7437520	496	10·2562480	60
1	9·6857991	379	0·3142009	9·9417492	117	0·0582508	9·7440499	496	10·2559501	59
2	9·6860267	379	0·3139733	9·9416791	117	0·0583209	9·7443476	496	10·2556524	58
3	9·6862542	379	0·3137458	9·9416090	117	0·0583910	9·7446453	496	10·2553547	57
4	9·6864816	379	0·3135184	9·9415388	117	0·0584612	9·7449428	496	10·2550572	56
5	9·6867088	378	0·3132912	9·9414685	117	0·0585315	9·7452403	495	10·2547597	55
6	9·6869359	378	0·3130641	9·9413982	117	0·0586018	9·7455376	495	10·2544624	54
7	9·6871628	378	0·3128372	9·9413279	117	0·0586721	9·7458349	495	10·2541651	53
8	9·6873895	378	0·3126105	9·9412575	117	0·0587425	9·7461320	495	10·2538680	52
9	9·6876161	377	0·3123839	9·9411871	117	0·0588129	9·7464290	495	10·2535710	51
10	9·6878425	377	0·3121575	9·9411166	117	0·0588834	9·7467259	495	10·2532741	50
11	9·6880688	377	0·3119312	9·9410461	118	0·0589539	9·7470227	494	10·2529773	49
12	9·6882949	377	0·3117051	9·9409755	118	0·0590245	9·7473194	494	10·2526806	48
13	9·6885209	376	0·3114791	9·9409048	118	0·0590952	9·7476160	494	10·2523840	47
14	9·6887467	376	0·3112533	9·9408342	118	0·0591658	9·7479125	494	10·2520875	46
15	9·6889723	376	0·3110277	9·9407634	118	0·0592366	9·7482089	494	10·2517911	45
16	9·6891978	376	0·3108022	9·9406927	118	0·0593073	9·7485052	494	10·2514948	44
17	9·6894232	375	0·3105768	9·9406219	118	0·0593781	9·7488013	493	10·2511987	43
18	9·6896484	375	0·3103516	9·9405510	118	0·0594490	9·7490974	493	10·2509026	42
19	9·6898734	375	0·3101266	9·9404801	118	0·0595199	9·7493934	493	10·2506066	41
20	9·6900983	375	0·3099017	9·9404091	118	0·0595909	9·7496892	493	10·2503108	40
21	9·6903231	374	0·3096769	9·9403381	118	0·0596619	9·7499850	493	10·2500150	39
22	9·6905476	374	0·3094524	9·9402670	118	0·0597330	9·7502806	493	10·2497194	38
23	9·6907721	374	0·3092279	9·9401959	118	0·0598041	9·7505762	492	10·2494238	37
24	9·6909964	374	0·3090036	9·9401248	119	0·0598752	9·7508716	492	10·2491284	36
25	9·6912205	373	0·3087795	9·9400535	119	0·0599465	9·7511669	492	10·2488331	35
26	9·6914445	373	0·3085555	9·9399823	119	0·0600177	9·7514622	492	10·2485378	34
27	9·6916683	373	0·3083317	9·9399110	119	0·0600890	9·7517573	492	10·2482427	33
28	9·6918919	373	0·3081081	9·9398396	119	0·0601604	9·7520523	491	10·2479477	32
29	9·6921155	372	0·3078845	9·9397682	119	0·0602318	9·7523472	491	10·2476528	31
30	9·6923388	372	0·3076612	9·9396968	119	0·0603032	9·7526420	491	10·2473580	30
31	9·6925620	372	0·3074380	9·9396253	119	0·0603747	9·7529368	491	10·2470632	29
32	9·6927851	371	0·3072149	9·9395537	119	0·0604463	9·7532314	491	10·2467686	28
33	9·6930080	371	0·3069920	9·9394821	119	0·0605179	9·7535259	491	10·2464741	27
34	9·6932308	371	0·3067692	9·9394105	119	0·0605895	9·7538203	490	10·2461797	26
35	9·6934534	371	0·3065466	9·9393388	119	0·0606612	9·7541146	490	10·2458854	25
36	9·6936758	370	0·3063242	9·9392671	120	0·0607329	9·7544088	490	10·2455912	24
37	9·6938981	370	0·3061019	9·9391953	120	0·0608047	9·7547029	490	10·2452971	23
38	9·6941203	370	0·3058797	9·9391234	120	0·0608766	9·7549969	490	10·2450031	22
39	9·6943423	370	0·3056577	9·9390515	120	0·0609485	9·7552908	490	10·2447092	21
40	9·6945642	369	0·3054358	9·9389796	120	0·0610204	9·7555846	489	10·2444154	20
41	9·6947859	369	0·3052141	9·9389076	120	0·0610924	9·7558783	489	10·2441217	19
42	9·6950074	369	0·3049926	9·9388356	120	0·0611644	9·7561718	489	10·2438282	18
43	9·6952288	369	0·3047712	9·9387635	120	0·0612365	9·7564653	489	10·2435347	17
44	9·6954501	368	0·3045499	9·9386914	120	0·0613086	9·7567587	489	10·2432413	16
45	9·6956712	368	0·3043288	9·9386192	120	0·0613808	9·7570520	489	10·2429480	15
46	9·6958922	368	0·3041078	9·9385470	120	0·0614530	9·7573452	488	10·2426548	14
47	9·6961130	368	0·3038870	9·9384747	120	0·0615253	9·7576383	488	10·2423617	13
48	9·6963336	367	0·3036664	9·9384024	121	0·0615976	9·7579313	488	10·2420687	12
49	9·6965541	367	0·3034459	9·9383300	121	0·0616700	9·7582242	488	10·2417758	11
50	9·6967745	367	0·3032255	9·9382576	121	0·0617424	9·7585170	488	10·2414830	10
51	9·6969947	367	0·3030053	9·9381851	121	0·0618149	9·7588096	488	10·2411904	9
52	9·6972148	366	0·3027852	9·9381126	121	0·0618874	9·7591022	487	10·2408978	8
53	9·6974347	366	0·3025653	9·9380400	121	0·0619600	9·7593947	487	10·2406053	7
54	9·6976545	366	0·3023455	9·9379674	121	0·0620326	9·7596871	487	10·2403129	6
55	9·6978741	366	0·3021259	9·9378947	121	0·0621053	9·7599794	487	10·2400206	5
56	9·6980936	365	0·3019064	9·9378220	121	0·0621780	9·7602716	487	10·2397284	4
57	9·6983129	365	0·3016871	9·9377492	121	0·0622508	9·7605637	486	10·2394363	3
58	9·6985321	365	0·3014679	9·9376764	121	0·0623236	9·7608557	486	10·2391443	2
59	9·6987511	365	0·3012489	9·9376035	121	0·0623965	9·7611476	486	10·2388524	1
60	9·6989700		0·3010300	9·9375306		0·0624694	9·7614394		10·2385606	0
′	Cosine	D 10″	Comp. cos.	Sine	D 10″	Comp. sin.	Cotang.	D 10″	Tangent	′

′	Sine	D10″	Comp. sin.	Cosine.	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·6989700	364	0·3010300	9·9375306	121	0·0624694	9·7614394	486	10·2385606	60
1	9·6991887	364	0·3008113	9·9374577	122	0·0625423	9·7617311	486	10·2382689	59
2	9·6994073	364	0·3005927	9·9373847	122	0·0626153	9·7620227	486	10·2379773	58
3	9·6996258	364	0·3003742	9·9373116	122	0·0626884	9·7623142	486	10·2376858	57
4	9·6998441	363	0·3001559	9·9372385	122	0·0627615	9·7626056	485	10·2373944	56
5	9·7000622	363	0·2999378	9·9371613	122	0·0628347	9·7628969	485	10·2371031	55
6	9·7002802	363	0·2997198	9·9370921	122	0·0629079	9·7631881	485	10·2368119	54
7	9·7004981	363	0·2995019	9·9370189	122	0·0629811	9·7634792	485	10·2365206	53
8	9·7007158	363	0·2992842	9·9369456	122	0·0630544	9·7637702	485	10·2362298	52
9	9·7009334	362	0·2990666	9·9368722	122	0·0631278	9·7640612	485	10·2359388	51
10	9·7011508	362	0·2988492	9·9367988	122	0·0632012	9·7643520	484	10·2356480	50
11	9·7013681	362	0·2986319	9·9367254	122	0·0632746	9·7646427	484	10·2353573	49
12	9·7015852	362	0·2984148	9·9366519	123	0·0633481	9·7649331	484	10·2350666	48
13	9·7018022	361	0·2981978	9·9365783	123	0·0634217	9·7652239	484	10·2347761	47
14	9·7020190	361	0·2979810	9·9365047	123	0·0634953	9·7655143	484	10·2344857	46
15	9·7022357	361	0·2977643	9·9364311	123	0·0635689	9·7658047	484	10·2341953	45
16	9·7024523	361	0·2975477	9·9363574	123	0·0636426	9·7660949	484	10·2339051	44
17	9·7026687	360	0·2973313	9·9362836	123	0·0637164	9·7663851	483	10·2336149	43
18	9·7028849	360	0·2971151	9·9362098	123	0·0637902	9·7666751	483	10·2333249	42
19	9·7031011	360	0·2968989	9·9361360	123	0·0638640	9·7669651	483	10·2330349	41
20	9·7033170	360	0·2966830	9·9360621	123	0·0639379	9·7672550	483	10·2327450	40
21	9·7035329	359	0·2964671	9·9359881	123	0·0640119	9·7675448	483	10·2324552	39
22	9·7037486	359	0·2962514	9·9359141	123	0·0640859	9·7678344	483	10·2321656	38
23	9·7039641	359	0·2960359	9·9358401	123	0·0641599	9·7681240	482	10·2318760	37
24	9·7041795	359	0·2958205	9·9357660	123	0·0642340	9·7684135	482	10·2315865	36
25	9·7043947	359	0·2956053	9·9356918	124	0·0643082	9·7687029	482	10·2312971	35
26	9·7046099	358	0·2953901	9·9356177	124	0·0643823	9·7889922	482	10·2310078	34
27	9·7048248	358	0·2951752	9·9355434	124	0·0644566	9·7692814	482	10·2307186	33
28	9·7050397	358	0·2949603	9·9354691	124	0·0645309	9·7695705	482	10·2304295	32
29	9·7052543	358	0·2947457	9·9353948	124	0·0646052	9·7698596	481	10·2301404	31
30	9·7054689	357	0·2945311	9·9358204	124	0·0646796	9·7701485	481	10·2298515	30
31	9·7056833	357	0·2943167	9·9352459	124	0·0647541	9·7704375	481	10·2295627	29
32	9·7058975	357	0·2941025	9·9351715	124	0·0648285	9·7707261	481	10·2292739	28
33	9·7061116	357	0·2938884	9·9350969	124	0·0649031	9·7710147	481	10·2289853	27
34	9·7063256	356	0·2936744	9·9350223	124	0·0649777	9·7713083	481	10·2286967	26
35	9·7065394	356	0·2934606	9·9349477	124	0·0650523	9·7715917	481	10·2284083	25
36	9·7067531	356	0·2932469	9·9348730	124	0·0651270	9·7718801	480	10·2281199	24
37	9·7069667	356	0·2930333	9·9347983	125	0·0652017	9·7721684	480	10·2278316	23
38	9·7071801	355	0·2928199	9·9347235	125	0·0652765	9·7724566	480	10·2275434	22
39	9·7073933	355	0·2926067	9·9346486	125	0·0653514	9·7727447	480	10·2272553	21
40	9·7076064	355	0·2923936	9·9345738	125	0·0654262	9·7730327	480	10·2269673	20
41	9·7078194	355	0·2921806	9·9344988	125	0·0655012	9·7733206	480	10·2266794	19
42	9·7080323	354	0·2919677	9·9344238	125	0·0655762	9·7736084	479	10·2263916	18
43	9·7082450	334	0·2917550	9·9343488	125	0·0656512	9·7738961	479	10·2261039	17
44	9·7084575	354	0·2915425	9·9342737	125	0·0657263	9·7741838	479	10·2258162	16
45	9·7086699	354	0·2913301	9·9341986	125	0·0658014	9·7744713	479	10·2255287	15
46	9·7088822	353	0·2911178	9·9341234	125	0·0658766	9·7747588	479	10·2252412	14
47	9·7090943	353	0·2909057	9·9340482	125	0·0659518	9·7750462	479	10·2249558	13
48	9·7093063	353	0·2906937	9·9339729	125	0·0660271	9·7753334	479	10·2246666	12
49	9·7095182	353	0·2904818	9·9338976	126	0·0661024	9·7756206	478	10·2243794	11
50	9·7097299	353	0·2902701	9·9338222	126	0·0661778	9·7759077	478	10·2240923	10
51	9·7099415	352	0·2900585	9·9337467	126	0·0662533	9·7761947	478	10·2238053	9
52	9·7101529	352	0·2898471	9·9336713	126	0·0663287	9·7764816	478	10·2235184	8
53	9·7103642	352	0·2896358	9·9335957	126	0·0664043	9·7767685	478	10·2232315	7
54	9·7105753	352	0·2894247	9·9335201	126	0·0664799	9·7770552	478	10·2229448	6
55	9·7107863	351	0·2892137	9·9334445	126	0·0665555	9·7773418	478	10·2226582	5
56	9·7109972	351	0·2890028	9·9333688	126	0·0666312	9·7776284	477	10·2223716	4
57	9·7112080	351	0·2887920	9·9332931	126	0·0667069	9·7779149	477	10·2220851	3
58	9·7114186	351	0·2885814	9·9332173	126	0·0667827	9·7782012	477	10·2217988	2
59	9·7116290	350	0·2883710	9·9331415	126	0·0668585	9·7784875	477	10·2215125	1
60	9·7118393		0·2881607	9·9330656		0·0669344	9·7787737		10·2212263	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotangent	D10″	Tangent	′

′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent.	′
0	9·7118393	350	0·2881607	9·9330656	126	0·0669344	9·7787737	477	10·2212263	60
1	9·7120495	350	0·2879505	9·9329897	127	0·0670103	9·7790599	477	10·2209401	59
2	9·7122596	350	0·2877404	9·9329137	127	0·0670863	9·7793459	477	10·2206541	58
3	9·7124695	349	0·2875305	9·9328376	127	0·0671624	9·7796318	476	10·2203682	57
4	9·7126792	349	0·2873208	9·9327616	127	0·0672384	9·7799177	476	10·2200823	56
5	9·7128889	349	0·2871111	9·9326854	127	0·0673146	9·7802034	476	10·2197966	55
6	9·7130983	349	0·2869017	9·9326092	127	0·0673908	9·7804891	476	10·2195109	54
7	9·7133077	349	0·2866923	9·9325330	127	0·0674670	9·7807747	476	10·2192253	53
8	9·7135169	348	0·2864831	9·9324567	127	0·0675483	9·7810602	476	10·2189398	52
9	9·7137260	348	0·2862740	9·9323804	127	0·0676196	9·7813456	476	10·2186544	51
10	9·7139349	348	0·2860651	9·9323040	127	0·0676960	9·7816309	475	10·2183691	50
11	9·7141437	348	0·2858563	9·9322276	127	0·0677724	9·7819162	475	10·2180838	49
12	9·7143524	347	0·2856476	9·9321511	127	0·0678489	9·7822013	475	10·2177987	48
13	9·7145609	347	0·2854391	9·9320746	128	0·0679254	9·7824864	475	10·2175136	47
14	9·7147693	347	0·2852307	9·9319980	128	0·0680020	9·7827713	475	10·2172287	46
15	9·7149776	347	0·2850224	9·9319213	128	0·0680787	9·7830562	475	10·2169438	45
16	9·7151827	347	0·2848143	9·9318447	128	0·0681553	9·7833410	475	10·2166590	44
17	9·7153937	346	0·2846063	9·9317679	128	0·0682321	9·7836258	474	10·2163742	43
18	9·7156015	346	0·2843985	9·9316911	128	0·0683089	9·7839104	474	10·2160896	42
19	9·7158092	346	0·2841908	9·9316143	128	0·0683857	9·7841949	474	10·2158051	41
20	9·7160168	346	0·2839832	9·9315374	128	0·0684626	9·7844794	474	10·2155206	40
21	9·7162243	345	0·2837757	9·9314605	128	0·0685395	9·7847638	474	10·2152362	39
22	9·7164316	345	0·2835684	9·9313835	128	0·0686165	9·7850481	474	10·2149519	38
23	9·7166387	345	0·2833613	9·9313065	128	0·0686935	9·7853323	473	10·2146677	37
24	9·7168458	345	0·2831542	9·9312294	129	0·0687706	9·7856164	473	10·2143836	36
25	9·7170526	345	0·2829474	9·9311522	129	0·0688478	9·7859004	473	10·2140996	35
26	9·7172594	344	0·2827406	9·9310750	129	0·0689250	9·7861844	473	10·2138156	34
27	9·7174660	344	0·2825340	9·9309978	129	0·0690022	9·7864682	473	10·2135318	33
28	9·7176725	344	0·2823275	9·9309205	129	0·0690795	9·7867520	473	10·2132480	32
29	9·7178789	344	0·2821211	9·9308432	129	0·0691568	9·7870357	473	10·2129643	31
30	9·7180851	343	0·2819149	9·9307658	129	0·0692342	9·7873193	472	10·2126807	30
31	9·7182912	343	0·2817088	9·9306883	129	0·0693117	9·7876028	472	10·2123972	29
32	9·7184971	343	0·2815029	9·9306109	129	0·0693891	9·7878863	472	10·2121137	28
33	9·7187030	343	0·2812970	9·9305333	129	0·0694667	9·7881696	472	10·2118504	27
34	9·7189086	343	0·2810914	9·9304557	129	0·0695443	9·7884529	472	10·2115471	26
35	9·7191142	342	0·2808858	9·9303781	129	0·0696219	9·7887361	472	10·2112639	25
36	9·7193196	342	0·2806804	9·9303004	130	0·0696996	9·7890192	472	10·2109808	24
37	9·7195249	342	0·2804751	9·9302226	130	0·0697774	9·7893023	472	10·2106977	23
38	9·7197300	342	0·2802700	9·9301448	130	0·0698552	9·7895852	471	10·2104148	22
39	9·7199350	341	0·2800650	9·9300670	130	0·0699330	9·7898681	471	10·2101319	21
40	9·7201399	341	0·2798601	9·9299891	130	0·0700109	9·7901508	471	10·2098492	20
41	9·7203447	341	0·2796553	9·9299112	130	0·0700888	9·7904335	471	10·2095665	19
42	9·7205493	341	0·2794507	9·9298332	130	0·0701668	9·7907161	471	10·2092839	18
43	9·7207538	340	0·2792462	9·9297551	130	0·0702449	9·7909987	471	10·2090013	17
44	9·7209581	340	0·2790419	9·9296770	130	0·0703230	9·7912811	471	10·2087189	16
45	9·7211623	340	0·2788377	9·9295989	130	0·0704011	9·7915635	470	10·2084365	15
46	9·7213664	340	0·2786336	9·9295207	130	0·0704793	9·7918458	470	10·2081542	14
47	9·7215704	340	0·2784296	9·9294424	130	0·0705576	9·7921280	470	10·2078720	13
48	9·7217742	339	0·2782258	9·9293641	131	0·0706359	9·7924101	470	10·2075899	12
49	9·7219779	339	0·2780221	9·9292857	131	0·0707143	9·7926921	470	10·2073079	11
50	9·7221814	339	0·2778186	9·9292073	131	0·0707927	9·7929741	470	10·2070259	10
51	9·7223848	339	0·2776152	9·9291289	131	0·0708711	9·7932560	470	10·2067440	9
52	9·7225881	339	0·2774119	9·9290504	131	0·0709496	9·7935378	469	10·2064622	8
53	9·7227913	338	0·2772087	9·9289718	131	0·0710282	9·7938195	469	10·2061805	7
54	9·7229943	338	0·2770057	9·9288932	131	0·0711068	9·7941011	469	10·2058989	6
55	9·7231972	338	0·2768028	9·9288145	131	0·0711855	9·7943827	469	10·2056173	5
56	9·7234000	338	0·2766000	9·9287358	131	0·0712642	9·7946641	469	10·2053359	4
57	9·7236026	337	0·2763974	9·9286571	131	0·0713429	9·7949455	469	10·2050545	3
58	9·7238051	337	0·2761949	9·9285783	131	0·0714217	9·7952268	469	10·2047732	2
59	9·7240075	337	0·2759925	9·9284994	131	0·0715006	9·7955081	468	10·2044919	1
60	9·7242097		0·2757903	9·9284205		0·0715795	9·7957892		10·2042108	0
′	Cosine	D10″	Comp.cos	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp.sin.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·7242097	337	0·2757903	9·9284205	132	0·0715795	9·7957892	468	10·2042108	60
1	9·7244118	337	0·2755882	9·9283415	132	0·0716585	9·7960703	468	10·2039297	59
2	9·7246138	336	0·2753862	9·9282625	132	0·0717375	9·7963513	468	10·2036487	58
3	9·7248156	336	0·2751844	9·9281834	132	0·0718166	9·7966322	468	10·2033678	57
4	9·7250174	336	0·2749826	9·9281043	132	0·0718957	9·7969130	468	10·2030870	56
5	9·7252189	336	0·2747811	9·9280251	132	0·0719749	9·7971938	468	10·2028062	55
6	9·7254204	335	0·2745796	9·9279459	132	0·0720541	9·7974745	468	10·2025255	54
7	9·7256217	335	0·2743783	9·9278666	132	0·0721334	9·7977551	467	10·2022449	53
8	9·7258229	335	0·2741771	9·9277873	132	0·0722127	9·7980356	467	10·2019644	52
9	9·7260240	335	0·2739760	9·9277079	132	0·0722921	9·7983160	467	10·2016840	51
10	9·7262249	335	0·2737751	9·9276285	132	0·0723715	9·7985964	467	10·2014036	50
11	9·7264257	334	0·2735743	9·9275496	132	0·0724510	9·7988767	467	10·2011233	49
12	9·7266264	334	0·2733736	9·9274695	133	0·0725305	9·7991569	467	10·2008431	48
13	9·7268269	334	0·2731731	9·9273899	133	0·0726101	9·7994370	467	10·2005630	47
14	9·7270273	334	0·2729727	9·9273103	133	0·0726897	9·7997170	467	10·2002830	46
15	9·7272276	334	0·2727724	9·9272306	133	0·0727694	9·7999970	466	10·2000030	45
16	9·7274278	333	0·2725722	9·9271509	133	0·0728491	9·8002769	466	10·1997231	44
17	9·7276278	333	0·2723722	9·9270711	133	0·0729289	9·8005567	466	10·1994433	43
18	9·7278277	333	0·2721723	9·9269913	133	0·0730087	9·8008365	466	10·1991635	42
19	9·7280275	333	0·2719725	9·9269114	133	0·0730886	9·8011161	466	10·1988839	41
20	9·7282271	333	0·2717729	9·9268314	133	0·0731686	9·8013957	466	10·1986043	40
21	9·7284267	332	0·2715733	9·9267514	133	0·0732486	9·8016752	466	10·1983248	39
22	9·7286260	332	0·2713740	9·9266714	133	0·0733286	9·8019546	466	10·1980454	38
23	9·7288253	332	0·2711747	9·9265913	133	0·0734087	9·8022340	465	10·1977660	37
24	9·7290244	332	0·2709756	9·9265112	134	0·0734888	9·8025133	465	10·1974867	36
25	9·7292234	331	0·2707766	9·9264310	134	0·0735690	9·8027925	465	10·1972075	35
26	9·7294223	331	0·2705777	9·9263507	134	0·0736493	9·8030716	465	10·1969284	34
27	9·7296211	331	0·2703789	9·9262704	134	0·0737296	9·8033506	465	10·1966494	33
28	9·7298197	331	0·2701803	9·9261901	134	0·0738099	9·8036296	465	10·1963704	32
29	9·7300182	331	0·2699818	9·9261096	134	0·0738904	9·8039085	465	10·1960915	31
30	9·7302165	330	0·2697835	9·9260292	134	0·0739708	9·8041873	465	10·1958127	30
31	9·7304148	330	0·2695852	9·9259487	134	0·0740513	9·8044661	464	10·1955339	29
32	9·7306129	330	0·2693871	9·9258681	134	0·0741319	9·8047447	464	10·1952553	28
33	9·7308109	330	0·2691891	9·9257875	134	0·0742125	9·8050233	464	10·1949767	27
34	9·7310087	329	0·2689913	9·9257069	134	0·0742931	9·8053019	464	10·1946981	26
35	9·7312064	329	0·2687936	9·9256261	134	0·0743739	9·8055803	464	10·1944197	25
36	9·7314040	329	0·2685960	9·9255454	135	0·0744546	9·8058587	464	10·1941413	24
37	9·7316015	329	0·2683985	9·9254646	135	0·0745354	9·8061370	464	10·1938630	23
38	9·7317989	329	0·2682011	9·9253837	135	0·0746163	9·8064152	463	10·1935848	22
39	9·7319961	328	0·2680039	9·9253028	135	0·0746972	9·8066933	463	10·1933067	21
40	9·7321932	328	0·2678068	9·9252218	135	0·0747782	9·8069714	463	10·1930286	20
41	9·7323902	328	0·2676098	9·9251408	135	0·0748592	9·8072494	463	10·1927506	19
42	9·7325870	328	0·2674130	9·9250597	135	0·0749403	9·8075273	463	10·1924727	18
43	9·7327837	328	0·2672163	9·9249786	135	0·0750214	9·8078052	463	10·1921948	17
44	9·7329803	327	0·2670197	9·9248974	135	0·0751026	9·8080829	463	10·1919171	16
45	9·7331768	327	0·2668232	9·9248161	135	0·0751839	9·8083606	463	10·1916394	15
46	9·7333731	327	0·2666269	9·9247349	136	0·0752651	9·8086383	462	10·1913617	14
47	9·7335693	327	0·2664307	9·9246535	136	0·0753465	9·8089158	462	10·1910842	13
48	9·7337654	327	0·2662346	9·9245721	136	0·0754279	9·8091933	462	10·1908067	12
49	9·7339614	326	0·2660386	9·9244907	136	0·0755093	9·8094707	462	10·1905293	11
50	9·7341572	326	0·2658428	9·9244092	136	0·0755908	9·8097480	462	10·1902520	10
51	9·7343529	326	0·2656471	9·9243277	136	0·0756723	9·8100253	462	10·1899747	9
52	9·7345485	326	0·2654515	9·9242461	136	0·0757539	9·8103025	462	10·1896975	8
53	9·7347440	325	0·2652560	9·9241644	136	0·0758356	9·8105796	462	10·1894204	7
54	9·7349393	325	0·2650607	9·9240827	136	0·0759173	9·8108566	462	10·1891434	6
55	9·7351345	325	0·2648655	9·9240010	136	0·0759990	9·8111336	461	10·1888664	5
56	9·7353296	325	0·2646704	9·9239191	136	0·0760809	9·8114105	461	10·1885895	4
57	9·7355246	325	0·2644754	9·9238373	136	0·0761627	9·8116873	461	10.1883127	3
58	9·7357195	324	0·2642805	9·9237554	137	0·0762446	9·8119641	461	10·1880359	2
59	9·7359142	324	0·2640858	9·9236734	137	0·0763266	9·8122408	461	10·1877592	1
60	9·7361088		0·2638912	9·9235914		0·0764086	9·8125174		10·1874826	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

′	Sine	D 10″	Comp.sin.	Cosine	D 10″	Comp.cos.	Tangent	D 10″	Cotangent	′
0	9·7361088	324	0·2638912	9·9235914	137	0·0764086	9·8125174	461	10·1874826	60
1	9·7363032	324	0·2636968	9·9235093	137	0·0764907	9·8127939	461	10·1872061	59
2	9·7364976	324	0·2635024	9·9234272	137	0·0765728	9·8130704	461	10·1869296	58
3	9·7366918	323	0·2633082	9·9233450	137	0·0766550	9·8133468	460	10·1866532	57
4	9·7368859	323	0·2631141	9·9232628	137	0·0767372	9·8136231	460	10·1863769	56
5	9·7370799	323	0·2629201	9·9231805	137	0·0768195	9·8138993	460	10·1861007	55
6	9·7372737	323	0·2627263	9·9230982	137	0·0769018	9·8141755	460	10·1858245	54
7	9·7374675	323	0·2625325	9·9230158	137	0·0769842	9·8144516	460	10·1855484	53
8	9·7376611	322	0·2623389	9·9229334	137	0·0770666	9·8147277	460	10·1852723	52
9	9·7378546	322	0·2621454	9·9228509	137	0·0771491	9·8150036	460	10·1849964	51
10	9·7380479	322	0·2619521	9·9227684	138	0·0772316	9·8152795	460	10·1847205	50
11	9·7382412	322	0·2617588	9·9226858	138	0·0773142	9·8155554	459	10·1844446	49
12	9·7384343	322	0·2615657	9·9226032	138	0·0773969	9·8158311	459	10·1841689	48
13	9·7386273	321	0·2613727	9·9225205	138	0·0774795	9·8161068	459	10·1838932	47
14	9·7388201	321	0·2611799	9·9224377	138	0·0775623	9·8163824	459	10·1836176	46
15	9·7390129	321	0·2609871	9·9223549	138	0·0776451	9·8166580	459	10·1833420	45
16	9·7392055	321	0·2607945	9·9222721	138	0·0777279	9·8169335	459	10·1830665	44
17	9·7393980	321	0·2606020	9·9221891	138	0·0778109	9·8172089	459	10·1827911	43
18	9·7395904	320	0·2604096	9·9221062	138	0·0778938	9·8174842	459	10·1825158	42
19	9·7397827	320	0·2602173	9·9220232	138	0·0779768	9·8177595	459	10·1822405	41
20	9·7399748	320	0·2600252	9·9219401	138	0·0780599	9·8180347	458	10·1819653	40
21	9·7401668	320	0·2598332	9·9218570	139	0·0781430	9·8183098	458	10·1816902	39
22	9·7403587	320	0·2596413	9·9217738	139	0·0782262	9·8185849	458	10·1814151	38
23	9·7405505	319	0·2594495	9·9216906	139	0·0783094	9·8188599	458	10·1811401	37
24	9·7407421	319	0·2592579	9·9216073	139	0·0783927	9·8191348	458	10·1808652	36
25	9·7409337	319	0·2590663	9·9215240	139	0·0784760	9·8194096	458	10·1805904	35
26	9·7411251	319	0·2588749	9·9214406	139	0·0785594	9·8196844	458	10·1803156	34
27	9·7413164	319	0·2586836	9·9213572	139	0·0786428	9·8199592	458	10·1800408	33
28	9·7415075	318	0·2584925	9·9212737	139	0·0787263	9·8202338	458	10·1797662	32
29	9·7416986	318	0·2583014	9·9211902	139	0·0788098	9·8205084	457	10·1794916	31
30	9·7418895	318	0·2581105	9·9211066	139	0·0788934	9·8207829	457	10·1792171	30
31	9·7420803	318	0·2579197	9·9210229	139	0·0789771	9·8210574	457	10·1789426	29
32	9·7422710	318	0·2577290	9·9209393	140	0·0790607	9·8213317	457	10·1786683	28
33	9·7424616	317	0·2575384	9·9208555	140	0·0791445	9·8216060	457	10·1783940	27
34	9·7426520	317	0·2573480	9·9207717	140	0·0792283	9·8218803	457	10·1781197	26
35	9·7428423	317	0·2571577	9·9206878	140	0·0793122	9·8221545	457	10·1778455	25
36	9·7430325	317	0·2569675	9·9206039	140	0·0793961	9·8224286	457	10·1775714	24
37	9·7432226	317	0·2567774	9·9205200	140	0·0794800	9·8227026	457	10·1772974	23
38	9·7434126	316	0·2565874	9·9204360	140	0·0795640	9·8229766	456	10·1770234	22
39	9·7436024	316	0·2563976	9·9203519	140	0·0796481	9·8232505	456	10·1767495	21
40	9·7437921	316	0·2562079	9·9202678	140	0·0797322	9·8235244	456	10·1764756	20
41	9·7439817	316	0·2560183	9·9201836	140	0·0798164	9·8237981	456	10·1762019	19
42	9·7441712	316	0·2558288	9·9200994	140	0·0799006	9·8240719	456	10·1759281	18
43	9·7443606	315	0·2556394	9·9200151	140	0·0799849	9·8243455	456	10·1756545	17
44	9·7445498	315	0·2554502	9·9199308	141	0·0800692	9·8246191	456	10·1753809	16
45	9·7447390	315	0·2552610	9·9198464	141	0·0801536	9·8248926	456	10·1751074	15
46	9·7449280	315	0·2550720	9·9197619	141	0·0802381	9·8251660	456	10·1748340	14
47	9·7451169	315	0·2548831	9·9196775	141	0·0803225	9·8254394	455	10·1745606	13
48	9·7453056	314	0·2546944	9·9195929	141	0·0804071	9·8257127	455	10·1742873	12
49	9·7454943	314	0·2545057	9·9195083	141	0·0804917	9·8259860	455	10·1740140	11
50	9·7456828	314	0·2543172	9·9194237	141	0·0805763	9·8262592	455	10·1737408	10
51	9·7458712	314	0·2541288	9·9193390	141	0·0806610	9·8265323	455	10·1734677	9
52	9·7460595	314	0·2539405	9·9192542	141	0·0807458	9·8268053	455	10·1731947	8
53	9·7462477	313	0·2537523	9·9191694	141	0·0808306	9·8270783	455	10·1729217	7
54	9·7464358	313	0·2535642	9·9190845	141	0·0809155	9·8273513	455	10·1726487	6
55	9·7466237	313	0·2533763	9·9189996	142	0·0810004	9·8276241	455	10·1723759	5
56	9·7468115	313	0·2531885	9·9189146	142	0·0810854	9·8278969	454	10·1721031	4
57	9·7469992	313	0·2530008	9·9188296	142	0·0811704	9·8281696	454	10·1718304	3
58	9·7471868	312	0·2528132	9·9187445	142	0·0812555	9·8284423	454	10·1715577	2
59	9·7473743	312	0·2526257	9·9186594	142	0·0813406	9·8287149	454	10·1712851	1
60	9·7475617		0·2524383	9·9185742		0·0814258	9·8289874		10·1710126	0
′	Cosine	D 10″	Comp.cos.	Sine	D 10″	Comp.sin.	Cotang.	D 10″	Tangent	′

′	Sine	D10″	Comp.sin	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·7475617	312	0·2524383	9·9185742	142	0·0814258	9·8289874	454	10·1710126	60
1	9·7477489	312	0·2522511	9·9184890	142	0·0815110	9·8292599	454	10·1707401	59
2	9·7479360	312	0·2520640	9·9184037	142	0·0815963	9·8295323	454	10·1704677	58
3	9·7481230	311	0·2518770	9·9183183	142	0·0816817	9·8298047	454	10·1701953	57
4	9·7483099	311	0·2516901	9·9182329	142	0·0817671	9·8300769	454	10·1699231	56
5	9·7484967	311	0·2515033	9·9181475	142	0·0818525	9·8303492	453	10·1696508	55
6	9·7486833	311	0·2513167	9·9180620	143	0·0819380	9·8306213	453	10·1693787	54
7	9·7488698	311	0·2511302	9·9179764	143	0·0820236	9·8308934	453	10·1691066	53
8	9·7490562	310	0·2509438	9·9178908	143	0·0821092	9·8311654	453	10·1688346	52
9	9·7492425	310	0·2507575	9·9178051	143	0·0821949	9·8314374	453	10·1685626	51
10	9·7494287	310	0·2505713	9·9177194	143	0·0822806	9·8317093	453	10·1682907	50
11	9·7496148	310	0·2503852	9·9176336	143	0·0823664	9·8319811	453	10·1680189	49
12	9·7498007	310	0·2501993	9·9175478	143	0·0824522	9·8322529	453	10·1677471	48
13	9·7499866	309	0·2500134	9·9174619	143	0·0825381	9·8325246	453	10·1674754	47
14	9·7501723	309	0·2498277	9·9173760	143	0·0826240	9·8327963	453	10·1672037	46
15	9·7503579	309	0·2496421	9·9172900	143	0·0827100	9·8330679	452	10·1669321	45
16	9·7505434	309	0·2494566	9·9172040	143	0·0827960	9·8333394	452	10·1666606	44
17	9·7507287	309	0·2492713	9·9171179	144	0·0828821	9·8336109	452	10·1663891	43
18	9·7509140	308	0·2490860	9·9170317	144	0·0829683	9·8338823	452	10·1661177	42
19	9·7510991	308	0·2489009	9·9169455	144	0·0830545	9·8341536	452	10·1658464	41
20	9·7512842	308	0·2487158	9·9168593	144	0·0831407	9·8344249	452	10·1655751	40
21	9·7514691	308	0·2485309	9·9167730	144	0·0832270	9·8346961	452	10·1653039	39
22	9·7516538	308	0·2483462	9·9166866	144	0·0833134	9·8349673	452	10·1650327	38
23	9·7518385	308	0·2481615	9·9166002	144	0·0833998	9·8352384	452	10·1647616	37
24	9·7520231	307	0·2479769	9·9165137	144	0·0834863	9·8355094	452	10·1644906	36
25	9·7522075	307	0·2477925	9·9164272	144	0·0835728	9·8357804	451	10·1642196	35
26	9·7523919	307	0·2476081	9·9163406	144	0·0836594	9·8360513	451	10·1639487	34
27	9·7525761	307	0·2474239	9·9162539	144	0·0837461	9·8363221	451	10·1636779	33
28	9·7527602	307	0·2472398	9·9161673	145	0·0838327	9·8365929	451	10·1634071	32
29	9·7529442	306	0·2470558	9·9160805	145	0·0839195	9·8368636	451	10·1631364	31
30	9·7531280	306	0·2468720	9·9159937	145	0·0840063	9·8371343	451	10·1628657	30
31	9·7533118	306	0·2466882	9·9159069	145	0·0840931	9·8374049	451	10·1625951	29
32	9·7534954	306	0·2465046	9·9158200	145	0·0841800	9·8376755	451	10·1623245	28
33	9·7536790	306	0·2463210	9·9157330	145	0·0842670	9·8379460	451	10·1620540	27
34	9·7538624	305	0·2461376	9·9156460	145	0·0843540	9·8382164	451	10·1617836	26
35	9·7540457	305	0·2459543	9·9155589	145	0·0844411	9·8384867	450	10·1615133	25
36	9·7542288	305	0·2457712	9·9154718	145	0·0845282	9·8387571	450	10·1612429	24
37	9·7544119	305	0·2455881	9·9153846	145	0·0846154	9·8390273	450	10·1609727	23
38	9·7545949	305	0·2454051	9·9152974	145	0·0847026	9·8392975	450	10·1607025	22
39	9·7547777	304	0·2452223	9·9152101	145	0·0847899	9·8395676	450	10·1604324	21
40	9·7549604	304	0·2450396	9·9151228	146	0·0848772	9·8398377	450	10·1601623	20
41	9·7551431	304	0·2448569	9·9150354	146	0·0849646	9·8401077	450	10·1598923	19
42	9·7553256	304	0·2446744	9·9149479	146	0·0850521	9·8403776	450	10·1596224	18
43	9·7555080	304	0·2444920	9·9148604	146	0·0851396	9·8406475	450	10·1593525	17
44	9·7556902	304	0·2443098	9·9147729	146	0·0852271	9·8409174	450	10·1590826	16
45	9·7558724	303	0·2441276	9·9146852	146	0·0853148	9·8411871	449	10·1588129	15
46	9·7560544	303	0·2439456	9·9145976	146	0·0854024	9·8414569	449	10·1585431	14
47	9·7562364	303	0·2437636	9·9145099	146	0·0854901	9·8417265	449	10·1582735	13
48	9·7564182	303	0·2435818	9·9144221	146	0·0855779	9·8419961	449	10·1580039	12
49	9·7565999	303	0·2434001	9·9143342	146	0·0856658	9·8422657	449	10·1577343	11
50	9·7567815	302	0·2432185	9·9142464	147	0·0857536	9·8425351	449	10·1574649	10
51	9·7569630	302	0·2430370	9·9141584	147	0·0858416	9·8428046	449	10·1571954	9
52	9·7571444	302	0·2428556	9·9140704	147	0·0859296	9·8430739	449	10·1569261	8
53	9·7573256	302	0·2426744	9·9139824	147	0·0860176	9·8433432	449	10·1566568	7
54	9·7575068	302	0·2424932	9·9138943	147	0·0861057	9·8436125	449	10·1563875	6
55	9·7576878	301	0·2423122	9·9138061	147	0·0861939	9·8438817	448	10·1561183	5
56	9·7578687	301	0·2421313	9·9137179	147	0·0862821	9·8441508	448	10·1558492	4
57	9·7580495	301	0·2419505	9·9136296	147	0·0863704	9·8444199	448	10·1555801	3
58	9·7582302	301	0·2417698	9·9135413	147	0·0864587	9·8446889	448	10·1553111	2
59	9·7584108	301	0·2415892	9·9134530	147	0·0865470	9·8449579	448	10·1550421	1
60	9·7585913		0·2414087	9·9133645		0·0866355	9·8452268		10·1547732	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin	Cotang.	D10″	Tangent	′

35 Deg. Tab. 18.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent.	′
0	9·7585913	301	0·2414087	9·9133645	147	0·0866355	9·8452268	448	10·1547732	60
1	9·7587717	300	0·2412283	9·9132760	147	0·0867240	9·8454956	448	10·1545044	59
2	9·7589519	300	0·2410481	9·9131875	148	0·0868125	9·8457644	448	10·1542356	58
3	9·7591321	300	0·2408679	9·9130989	148	0·0869011	9·8460332	448	10·1539668	57
4	9·7593121	300	0·2406879	9·9130102	148	0·0869898	9·8463018	448	10·1536982	56
5	9·7594920	300	0·2405080	9·9129215	148	0·0870785	9·8465705	447	10·1534295	55
6	9·7596718	299	0·2403282	9·9128328	148	0·0871672	9·8468390	447	10·1531610	54
7	9·7598515	299	0·2401485	9·9127440	148	0·0872560	9·8471075	447	10·1528925	53
8	9·7600311	299	0·2399689	9·9126551	148	0·0873449	9·8473760	447	10·1526240	52
9	9·7602106	299	0·2397894	9·9125662	148	0·0874338	9·8476444	447	10·1523556	51
10	9·7603899	299	0·2396101	9·9124772	148	0·0875228	9·8479127	447	10·1520873	50
11	9·7605692	298	0·2394308	9·9123882	148	0·0876118	9·8481810	447	10·1518190	49
12	9·7607483	298	0·2392517	9·9122991	149	0·0877009	9·8484492	447	10·1515508	48
13	9·7609274	298	0·2390726	9·9122099	149	0·0877901	9·8487174	447	10·1512826	47
14	9·7611063	298	0·2388937	9·9121207	149	0·0878793	9·8489855	447	10·1510145	46
15	9·7612851	298	0·2387149	9·9120315	149	0·0879685	9·8492536	447	10·1507464	45
16	9·7614638	298	0·2385362	9·9119422	149	0·0880578	9·8495216	447	10·1504784	44
17	9·7616424	297	0·2383576	9·9118528	149	0·0881472	9·8497896	446	10·1502104	43
18	9·7618208	297	0·2381792	9·9117634	149	0·0882366	9·8500575	446	10·1499425	42
19	9·7619992	297	0·2380008	9·9116739	149	0·0883261	9·8503253	446	10·1496747	41
20	9·7621775	297	0·2378225	9·9115844	149	0·0884156	9·8505931	446	10·1494069	40
21	9·7623556	297	0·2376444	9·9114948	149	0·0885052	9·8508608	446	10·1491392	39
22	9·7625337	296	0·2374663	9·9114051	149	0·0885949	9·8511285	446	10·1488715	38
23	9·7627116	296	0·2372884	9·9113155	150	0·0886845	9·8513961	446	10·1486039	37
24	9·7628894	296	0·2371106	9·9112257	150	0·0887743	9·8516637	446	10·1483363	36
25	9·7630671	296	0·2369329	9·9111359	150	0·0888641	9·8519312	446	10·1480688	35
26	9·7632447	296	0·2367553	9·9110460	150	0·0889540	9·8521987	446	10·1478013	34
27	9·7634222	296	0·2365778	9·9109561	150	0·0890439	9·8524661	446	10·1475339	33
28	9·7635996	295	0·2364004	9·9108661	150	0·0891339	9·8527335	445	10·1472665	32
29	9·7637769	295	0·2362231	9·9107761	150	0·0892239	9·8530008	445	10·1469992	31
30	9·7639540	295	0·2360460	9·9106860	150	0·0893140	9·8532680	445	10·1467320	30
31	9·7641311	295	0·2358689	9·9105959	150	0·0894041	9·8535352	445	10·1464648	29
32	9·7643080	295	0·2356920	9·9105057	150	0·0894943	9·8538023	445	10·1461977	28
33	9·7644849	294	0·2355151	9·9104155	150	0·0895845	9·8540694	445	10·1459306	27
34	9·7646616	294	0·2353384	9·9103251	151	0·0896749	9·8543365	445	10·1456635	26
35	9·7648382	294	0·2351618	9·9102348	151	0·0897652	9·8546034	445	10·1453966	25
36	9·7650147	294	0·2349853	9·9101444	151	0·0898556	9·8548704	445	10·1451296	24
37	9·7651911	294	0·2348089	9·9100539	151	0·0899461	9·8551372	445	10·1448628	23
38	9·7653674	294	0·2346326	9·9099634	151	0·0900366	9·8554041	445	10·1445959	22
39	9·7655436	293	0·2344564	9·9098728	151	0·0901272	9·8556708	444	10·1443292	21
40	9·7657197	293	0·2342803	9·9097821	151	0·0902179	9·8559376	444	10·1440624	20
41	9·7658957	293	0·2341043	9·9096915	151	0·0903085	9·8562042	444	10·1437958	19
42	9·7660715	293	0·2339285	9·9096007	151	0·0903993	9·8564708	444	10·1435292	18
43	9·7662473	293	0·2337527	9·9095099	151	0·0904901	9·8567374	444	10·1432626	17
44	9·7664229	293	0·2335771	9·9094190	151	0·0905810	9·8570039	444	10·1429961	16
45	9·7665985	292	0·2334015	9·9093281	152	0·0906719	9·8572704	444	10·1427296	15
46	9·7667739	292	0·2332261	9·9092371	152	0·0907629	9·8575368	444	10·1424632	14
47	9·7669492	292	0·2330508	9·9091461	152	0·0908539	9·8578031	444	10·1421969	13
48	9·7671244	292	0·2328756	9·9090550	152	0·0909450	9·8580694	444	10·1419306	12
49	9·7672996	292	0·2327004	9·9089639	152	0·0910361	9·8583357	444	10·1416643	11
50	9·7674746	291	0·2325254	9·9088727	152	0·0911273	9·8586019	443	10·1413981	10
51	9·7676494	291	0·2323506	9·9087814	152	0·0912186	9·8588680	443	10·1411320	9
52	9·7678242	291	0·2321758	9·9086901	152	0·0913099	9·8591341	443	10·1408659	8
53	9·7679989	291	0·2320011	9·9085988	152	0·0914012	9·8594002	443	10·1405998	7
54	9·7681735	291	0·2318265	9·9085073	152	0·0914927	9·8596661	443	10·1403339	6
55	9·7683480	290	0·2316520	9·9084159	153	0·0915841	9·8599321	443	10·1400679	5
56	9·768522	290	0·2314777	9·9083243	153	0·0916757	9·8601980	443	10·1398020	4
57	9·7686966	290	0·2313034	9·9082327	153	0·0917673	9·8604638	443	10·1395362	3
58	9·7688707	290	0·2311293	9·9081411	153	0·0918589	9·8607296	443	10·1392704	2
59	9·7690448	290	0·2309552	9·9080494	153	0·0919506	9·8609954	443	10·1390046	1
60	9·7692187		0·2307813	9·9079576		0·0920424	9·8612610		10·1387390	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·7692187	290	0·2307813	9·9079576	153	0·0920424	9·8612610	443	10·1387390	60
1	9·7693925	289	0·2306075	9·9078658	153	0·0921342	9·8615267	443	10·1384733	59
2	9·7695662	289	0·2304338	9·9077740	153	0·0922260	9·8617923	442	10·1382077	58
3	9·7697398	289	0·2302602	9·9076820	153	0·0923180	9·8620578	442	10·1379422	57
4	9·7699134	289	0·2300866	9·9075901	153	0·0924099	9·8623233	442	10·1376767	56
5	9·7700868	289	0·2299132	9·9074980	153	0·0925020	9·8625887	442	10·1374113	55
6	9·7702601	288	0·2297399	9·9074059	153	0·0925541	9·8628541	442	10·1371459	54
7	9·7704332	288	0·2295668	9·9073138	154	0·0926862	9·8631195	442	10·1368805	53
8	9·7706063	288	0·2293937	9·9072216	154	0·0927784	9·8633848	442	10·1366152	52
9	9·7707793	288	0·2292207	9·9071293	154	0·0928707	9·8636500	442	10·1363500	51
10	9·7709522	288	0·2290478	9·9070370	154	0·0929630	9·8639152	442	10·1360848	50
11	9·7711249	288	0·2288751	9·9069446	154	0·0930554	9·8641803	442	10·1358197	49
12	9·7712976	288	0·2287024	9·9068522	154	0·0931478	9·8644454	442	10·1355546	48
13	9·7714702	287	0·2285298	9·9067597	154	0·0932403	9·8647105	442	10·1352895	47
14	9·7716426	287	0·2283574	9·9066671	154	0·0933329	9·8649755	441	10·1350245	46
15	9·7718150	287	0·2281850	9·9065745	154	0·0934255	9·8652404	441	10·1347596	45
16	9·7719872	287	0·2280128	9·9064819	154	0·0935181	9·8655053	441	10·1344947	44
17	9·7721593	287	0·2278407	9·9063892	155	0·0936108	9·8657702	441	10·1342298	43
18	9·7723314	286	0·2276686	9·9062964	155	0·0937036	9·8660350	441	10·1339650	42
19	9·7725033	286	0·2274967	9·9062036	155	0·0937964	9·8662997	441	10·1337003	41
20	9·7726751	286	0·2273249	9·9061107	155	0·0938893	9·8665644	441	10·1334356	40
21	9·7728468	286	0·2271532	9·9060177	155	0·0939823	9·8668291	441	10·1331709	39
22	9·7730185	286	0·2269815	9·9059247	155	0·0940753	9·8670937	441	10·1329063	38
23	9·7731900	286	0·2268100	9·9058317	155	0·0941683	9·8673582	441	10·1326417	37
24	9·7733614	285	0·2266386	9·9057386	155	0·0942614	9·8676228	441	10·1323772	36
25	9·7735327	285	0·2264673	9·9056454	155	0·0943546	9·8678873	441	10·1321127	35
26	9·7737039	285	0·2262961	9·9055522	155	0·0944478	9·8681517	441	10·1318483	34
27	9·7738749	285	0·2261251	9·9054589	155	0·0945411	9·8684160	440	10·1315840	33
28	9·7740459	285	0·2259541	9·9053656	156	0·0946344	9·8686804	440	10·1313196	32
29	9·7742168	285	0·2257832	9·9052722	156	0·0947278	9·8689446	440	10·1310554	31
30	9·7743876	284	0·2256124	9·9051787	156	0·0948213	9·8692089	440	10·1307911	30
31	9·7745583	284	0·2254417	9·9050852	156	0·0949148	9·8694731	440	10·1305269	29
32	9·7747288	284	0·2252712	9·9049916	156	0·0950084	9·8697372	440	10·1302628	28
33	9·7748993	284	0·2251007	9·9048980	156	0·0951020	9·8700013	440	10·1299987	27
34	9·7750697	284	0·2249303	9·9048043	156	0·0951957	9·8702653	440	10·1297347	26
35	9·7752399	284	0·2247601	9·9047106	156	0·0952894	9·8705293	440	10·1294707	25
36	9·7754101	283	0·2245899	9·9046168	156	0·0953832	9·8707933	440	10·1292067	24
37	9·7755801	283	0·2244199	9·9045230	156	0·0954770	9·8710572	440	10·1289428	23
38	9·7757501	283	0·2242499	9·9044291	157	0·0955709	9·8713210	440	10·1286790	22
39	9·7759199	283	0·2240801	9·9043351	157	0·0956649	9·8715848	440	10·1284152	21
40	9·7760897	283	0·2239103	9·9042411	157	0·0957589	9·8718486	439	10·1281514	20
41	9·7762593	283	0·2237407	9·9041470	157	0·0958530	9·8721123	439	10·1278877	19
42	9·7764289	282	0·2235711	9·9040529	157	0·0959471	9·8723760	439	10·1276240	18
43	9·7765983	282	0·2234017	9·9039587	157	0·0960413	9·8726396	439	10·1273604	17
44	9·7767676	282	0·2232324	9·9038644	157	0·0961356	9·8729032	439	10·1270968	16
45	9·7769369	282	0·2230631	9·9037701	157	0·0962299	9·8731668	439	10·1268332	15
46	9·7771060	282	0·2228940	9·9036757	157	0·0963243	9·8734302	439	10·1265698	14
47	9·7772750	281	0·2227250	9·9035813	157	0·0964187	9·8736937	439	10·1263063	13
48	9·7774439	281	0·2225561	9·9034868	157	0·0965132	9·8739571	439	10·1260429	12
49	9·7776128	281	0·2223872	9·9033923	158	0·0966077	9·8742204	439	10·1257796	11
50	9·7777815	281	0·2222185	9·9032977	158	0·0967023	9·8744838	439	10·1255162	10
51	9·7779501	281	0·2220499	9·9032031	158	0·0967969	9·8747470	439	10·1252530	9
52	9·7781186	281	0·2218814	9·9031084	158	0·0968916	9·8750102	439	10·1249898	8
53	9·7782870	280	0·2217130	9·9030136	158	0·0969864	9·8752734	438	10·1247266	7
54	9·7784553	280	0·2215447	9·9029188	158	0·0970812	9·8755365	438	10·1244635	6
55	9·7786235	280	0·2213765	9·9028239	158	0·0971761	9·8757996	438	10·1242004	5
56	9·7787916	280	0·2212084	9·9027289	158	0·0972711	9·8760627	438	10·1239373	4
57	9·7789596	280	0·2210404	9·9026339	158	0·0973661	9·8763257	438	10·1236743	3
58	9·7791275	280	0·2208725	9·9025389	158	0·0974611	9·8765886	438	10·1234114	2
59	9·7792953	279	0·2207047	9·9024438	159	0·0975562	9·8768515	438	10·1231485	1
60	9·7794630		0·2205370	9·9023486		0·0976514	9·8771144		10·1228856	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

37 Deg. Tab. 16.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·7794630	279	0·2205370	9·9023486	159	0·0976514	9·8771144	438	10·1228856	60
1	9·7796306	279	0·2203694	9·9022534	159	0·0977466	9·8773772	438	10·1226228	59
2	9·7797981	279	0·2202019	9·9021581	159	0·0978419	9·8776400	438	10·1223600	58
3	9·7799655	279	0·2200345	9·9020628	159	0·0979372	9·8779027	438	10·1220973	57
4	9·7801328	279	0·2198672	9·9019674	159	0·0980326	9·8781654	438	10·1218346	56
5	9·7803000	278	0·2197000	9·9018719	159	0·0981281	9·8784281	438	10·1215719	55
6	9·7804671	278	0·2195329	9·9017764	159	0·0982236	9·8786907	438	10·1213093	54
7	9·7806341	278	0·2193659	9·9016808	159	0·0983192	9·8789533	437	10·1210467	53
8	9·7808010	278	0·2191990	9·9015852	159	0·0984148	9·8792158	437	10·1207842	52
9	9·7809677	278	0·2190323	9·9014895	159	0·0985105	9·8794782	437	10·1205218	51
10	9·7811344	278	0·2188656	9·9013938	160	0·0986062	9·8797407	437	10·1202593	50
11	9·7813010	277	0·2186990	9·9012980	160	0·0987020	9·8800031	437	10·1199969	49
12	9·7814675	277	0·2185325	9·9012021	160	0·0987979	9·8802654	437	10·1197346	48
13	9·7816339	277	0·2183661	9·9011062	160	0·0988938	9·8805277	437	10·1194723	47
14	9·7818002	277	0·2181998	9·9010102	160	0·0989898	9·8807900	437	10·1192100	46
15	9·7819664	277	0·2180336	9·9009142	160	0·0990858	9·8810522	437	10·1189478	45
16	9·7821324	277	0·2178676	9·9008181	160	0·0991819	9·8813144	437	10·1186856	44
17	9·7822984	276	0·2177016	9·9007219	160	0·0992781	9·8815765	437	10·1184235	43
18	9·7824643	276	0·2175357	9·9006257	160	0·0993743	9·8818386	437	10·1181614	42
19	9·7826301	276	0·2173699	9·9005294	160	0·0994706	9·8821007	437	10·1178993	41
20	9·7827958	276	0·2172042	9·9004331	161	0·0995669	9·8823627	437	10·1176373	40
21	9·7829614	276	0·2170386	9·9003367	161	0·0996633	9·8826246	436	10·1173754	39
22	9·7831268	276	0·2168732	9·9002403	161	0·0997597	9·8828866	436	10·1171134	38
23	9·7832922	275	0·2167078	9·9001438	161	0·0998562	9·8831484	436	10·1168516	37
24	9·7834575	275	0·2165425	9·9000472	161	0·0999528	9·8834103	436	10·1165897	36
25	9·7836227	275	0·2163773	9·8999506	161	0·1000494	9·8836721	436	10·1163279	35
26	9·7837878	275	0·2162122	9·8998539	161	0·1001461	9·8839338	436	10·1160662	34
27	9·7839528	275	0·2160472	9·8997572	161	0·1002428	9·8841956	436	10·1158044	33
28	9·7841177	274	0·2158823	9·8996604	161	0·1003396	9·8844572	436	10·1155428	32
29	9·7842824	274	0·2157176	9·8995636	161	0·1004364	9·8847189	436	10·1152811	31
30	9·7844471	274	0·2155529	9·8994657	162	0·1005333	9·8849805	436	10·1150195	30
31	9·7846117	274	0·2153883	9·8993697	162	0·1006303	9·8852420	436	10·1147580	29
32	9·7847762	274	0·2152238	9·8992727	162	0·1007273	9·8855035	436	10·1144965	28
33	9·7849406	274	0·2150594	9·8991756	162	0·1008244	9·8857650	436	10·1142350	27
34	9·7851049	274	0·2148951	9·8990784	162	0·1009216	9·8860264	436	10·1139736	26
35	9·7852691	273	0·2147309	9·8989812	162	0·1010188	9·8862878	436	10·1137122	25
36	9·7854332	273	0·2145668	9·8988840	162	0·1011160	9·8865492	435	10·1134508	24
37	9·7855972	273	0·2144028	9·8987867	162	0·1012133	9·8868105	435	10·1131895	23
38	9·7857611	273	0·2142389	9·8986893	162	0·1013107	9·8870718	435	10·1129282	22
39	9·7859249	273	0·2140751	9·8985919	162	0·1014081	9·8873330	435	10·1126670	21
40	9·7860886	273	0·2139114	9·8984944	163	0·1015056	9·8875942	435	10·1124058	20
41	9·7862522	272	0·2137478	9·8983968	163	0·1016032	9·8878554	435	10·1121446	19
42	9·7864157	272	0·2135843	9·8982992	163	0·1017008	9·8881165	435	10·1118835	18
43	9·7865791	272	0·2134209	9·8982015	163	0·1017985	9·8883775	435	10·1116225	17
44	9·7867424	272	0·2132576	9·8981038	163	0·1018962	9·8886386	435	10·1113614	16
45	9·7869056	272	0·2130944	9·8980060	163	0·1019940	9·8888996	435	10·1111004	15
46	9·7870687	272	0·2129313	9·8979082	163	0·1020918	9·8891605	435	10·1108395	14
47	9·7872317	271	0·2127683	9·8978103	163	0·1021897	9·8894214	435	10·1105786	13
48	9·7873946	271	0·2126054	9·8977123	163	0·1022877	9·8896823	435	10·1103177	12
49	9·7875574	271	0·2124426	9·8976143	163	0·1023857	9·8899432	435	10·1100568	11
50	9·7877202	271	0·2122798	9·8975162	163	0·1024838	9·8902040	434	10·1097960	10
51	9·7878828	271	0·2121172	9·8974181	164	0·1025819	9·8904647	434	10·1095353	9
52	9·7880453	271	0·2119547	9·8973199	164	0·1026801	9·8907254	434	10·1092746	8
53	9·7882077	271	0·2117923	9·8972216	164	0·1027784	9·8909861	434	10·1090139	7
54	9·7883701	270	0·2116299	9·8971233	164	0·1028767	9·8912468	434	10·1087532	6
55	9·7885323	270	0·2114677	9·8970249	164	0·1029751	9·8915074	434	10·1084926	5
56	9·7886944	270	0·2113056	9·8969265	164	0·1030735	9·8917679	434	10·1082321	4
57	9·7888565	270	0·2111435	9·8968280	164	0·1031720	9·8920285	434	10·1079715	3
58	9·7890184	270	0·2109816	9·8967294	164	0·1032706	9·8922890	434	10·1077110	2
59	9·7891802	270	0·2108198	9·8966308	164	0·1033692	9·8925494	434	10·1074506	1
60	9·7893420		0·2106580	9·8965321		0·1034679	9·8928098		10·1071902	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

'	Sine	D10"	Comp. sin.	Cosine	D10"	Comp. cos.	Tangent	D10"	Cotangent	'
0	9·7893420	269	0·2106580	9·8965321	164	0·1034679	9·8928099	434	10·1071901	60
1	9·7895036	269	0·2104964	9·8964334	165	0·1035666	9·8930702	434	10·1069298	59
2	9·7896652	269	0·2103348	9·8963346	165	0·1036654	9·8933306	434	10·1066694	58
3	9·7898266	269	0·2101734	9·8962358	165	0·1037642	9·8935908	434	10·1064092	57
4	9·7899880	269	0·2100120	9·8961369	165	0·1038631	9·8938511	434	10·1061489	56
5	9·7901493	269	0·2098507	9·8960379	165	0·1039621	9·8941114	433	10·1058886	55
6	9·7903104	268	0·2096896	9·8959389	165	0·1040611	9·8943715	433	10·1056285	54
7	9·7904715	268	0·2095285	9·8958398	165	0·1041602	9·8946317	433	10·1053683	53
8	9·7906325	268	0·2093675	9·8957406	165	0·1042594	9·8948918	433	10·1051082	52
9	9·7907933	268	0·2092067	9·8956414	165	0·1043586	9·8951519	433	10·1048481	51
10	9·7909541	268	0·2090459	9·8955422	165	0·1044578	9·8954119	433	10·1045881	50
11	9·7911148	268	0·2088852	9·8954429	166	0·1045571	9·8956719	433	10·1043281	49
12	9·7912754	267	0·2087246	9·8953435	166	0·1046565	9·8959319	433	10·1040681	48
13	9·7914359	267	0·2085641	9·8952440	166	0·1047560	9·8961918	433	10·1038082	47
14	9·7915963	267	0·2084037	9·8951445	166	0·1048555	9·8964517	433	10·1035483	46
15	9·7917566	267	0·2082434	9·8950450	166	0·1049550	9·8967116	433	10·1032884	45
16	9·7919168	267	0·2080832	9·8949453	166	0·1050547	9·8969714	433	10·1030286	44
17	9·7920769	267	0·2079231	9·8948457	166	0·1051543	9·8972312	433	10·1027688	43
18	9·7922369	266	0·2077631	9·8947459	166	0·1052541	9·8974910	433	10·1025090	42
19	9·7923968	266	0·2076032	9·8946461	166	0·1053539	9·8977507	433	10·1022493	41
20	9·7925566	266	0·2074434	9·8945463	166	0·1054537	9·8980104	433	10·1019896	40
21	9·7927163	266	0·2072837	9·8944463	167	0·1055537	9·8982700	433	10·1017300	39
22	9·7928760	266	0·2071240	9·8943464	167	0·1056536	9·8985296	433	10·1014704	38
23	9·7930355	266	0·2069645	9·8942463	167	0·1057537	9·8987892	432	10·1012108	37
24	9·7931949	266	0·2068051	9·8941462	167	0·1058538	9·8990487	432	10·1009513	36
25	9·7933543	265	0·2066457	9·8940461	167	0·1059539	9·8993082	432	10·1006918	35
26	9·7935135	265	0·2064865	9·8939458	167	0·1060542	9·8995677	432	10·1004323	34
27	9·7936727	265	0·2063273	9·8938456	167	0·1061544	9·8998271	432	10·1001729	33
28	9·7938317	265	0·2061683	9·8937452	167	0·1062548	9·9000865	432	10·0999135	32
29	9·7939907	265	0·2060093	9·8936448	167	0·1063552	9·9003459	432	10·0996541	31
30	9·7941496	265	0·2058504	9·8935444	167	0·1064556	9·9006052	432	10·0993948	30
31	9·7943083	264	0·2056917	9·8934439	168	0·1065561	9·9008645	432	10·0991355	29
32	9·7944670	264	0·2055330	9·8933433	168	0·1066567	9·9011237	432	10·0988763	28
33	9·7946256	264	0·2053744	9·8932426	168	0·1067574	9·9013830	432	10·0986170	27
34	9·7947841	264	0·2052159	9·8931419	168	0·1068581	9·9016422	432	10·0983578	26
35	9·7949425	264	0·2050575	9·8930412	168	0·1069588	9·9019013	432	10·0980987	25
36	9·7951008	264	0·2048992	9·8929404	168	0·1070596	9·9021604	432	10·0978396	24
37	9·7952590	263	0·2047410	9·8928395	168	0·1071605	9·9024195	432	10·0975805	23
38	9·7954171	263	0·2045829	9·8927385	168	0·1072615	9·9026786	432	10·0973214	22
39	9·7955751	263	0·2044249	9·8926375	168	0·1073625	9·9029376	432	10·0970624	21
40	9·7957330	263	0·2042670	9·8925365	168	0·1074635	9·9031966	431	10·0968034	20
41	9·7958909	263	0·2041091	9·8924354	169	0·1075646	9·9034555	431	10·0965445	19
42	9·7960486	263	0·2039514	9·8923342	169	0·1076658	9·9037144	431	10·0962856	18
43	9·7962062	263	0·2037938	9·8922329	169	0·1077671	9·9039733	431	10·0960267	17
44	9·7963638	262	0·2036362	9·8921316	169	0·1078684	9·9042321	431	10·0957679	16
45	9·7965212	262	0·2034788	9·8920303	169	0·1079697	9·9044910	431	10·0955090	15
46	9·7966786	262	0·2033214	9·8919289	169	0·1080711	9·9047497	431	10·0952503	14
47	9·7968359	262	0·2031641	9·8918274	169	0·1081726	9·9050085	431	10·0949915	13
48	9·7969930	262	0·2030070	9·8917258	169	0·1082742	9·9052672	431	10·0947328	12
49	9·7971501	262	0·2028499	9·8916242	169	0·1083758	9·9055259	431	10·0944741	11
50	9·7973071	261	0·2026929	9·8915226	169	0·1084774	9·9057845	431	10·0942155	10
51	9·7974640	261	0·2025360	9·8914208	170	0·1085792	9·9060431	431	10·0939569	9
52	9·7976208	261	0·2023792	9·8913191	170	0·1086809	9·9063017	431	10·0936983	8
53	9·7977775	261	0·2022225	9·8912172	170	0·1087828	9·9065603	431	10·0934397	7
54	9·7979341	261	0·2020659	9·8911153	170	0·1088847	9·9068188	431	10·0931812	6
55	9·7980906	261	0·2019094	9·8910133	170	0·1089867	9·9070773	431	10·0929227	5
56	9·7982470	261	0·2017530	9·8909113	170	0·1090887	9·9073357	431	10·0926643	4
57	9·7984034	260	0·2015966	9·8908092	170	0·1091908	9·9075941	431	10·0924059	3
58	9·7985596	260	0·2014404	9·8907071	170	0·1092929	9·9078525	431	10·0921475	2
59	9·7987158	260	0·2012842	9·8906049	170	0·1093951	9·9081109	431	10·0918891	1
60	9·7988718		0·2011282	9·8905026		0·1094974	9·9083692		10·0916308	0
'	Cosine	D10"	Comp. cos.	Sine	D10"	Comp. sin.	Cotangent	D10"	Tangent	'

39 Deg. Tab. 15.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·7988718	260	0·2011282	9·8905026	170	0·1094974	9·9083692	430	10·0916308	60
1	9·7990278	260	0·2009722	9·8904003	171	0·1095997	9·9086275	430	10·0913725	59
2	9·7991836	260	0·2008164	9·8902979	171	0·1097021	9·9088858	430	10·0911142	58
3	9·7993394	259	0·2006606	9·8901954	171	0·1098046	9·9091440	430	10·0908560	57
4	9·7994951	259	0·2005049	9·8900929	171	0·1099071	9·9094022	430	10·0905978	56
5	9·7996507	259	0·2003493	9·8899903	171	0·1100097	9·9096603	430	10·0903397	55
6	9·7998062	259	0·2001938	9·8898877	171	0·1101123	9·9099185	430	10·0900815	54
7	9·7999616	259	0·2000384	9·8897850	171	0·1102150	9·9101766	430	10·0898234	53
8	9·8001169	259	0·1998831	9·8896822	171	0·1103178	9·9104347	430	10·0895653	52
9	9·8002721	258	0·1997279	9·8895794	171	0·1104206	9·9106927	430	10·0893073	51
10	9·8004272	258	0·1995728	9·8894765	171	0·1105235	9·9109507	430	10·0890493	50
11	9·8005823	258	0·1994177	9·8893736	172	0·1106264	9·9112087	430	10·0887913	49
12	9·8007372	258	0·1992628	9·8892706	172	0·1107294	9·9114666	430	10·0885334	48
13	9·8008921	258	0·1991079	9·8891675	172	0·1108325	9·9117245	430	10·0882755	47
14	9·8010468	258	0·1989532	9·8890644	172	0·1109356	9·9119824	430	10·0880176	46
15	9·8012015	258	0·1987985	9·8889612	172	0·1110388	9·9122403	430	10·0877597	45
16	9·8013561	257	0·1986439	9·8888580	172	0·1111420	9·9124981	430	10·0875019	44
17	9·8015106	257	0·1984894	9·8887547	172	0·1112453	9·9127559	430	10·0872441	43
18	9·8016649	257	0·1983351	9·8886513	172	0·1113487	9·9130137	429	10·0869863	42
19	9·8018192	257	0·1981808	9·8885479	172	0·1114521	9·9132714	429	10·0867286	41
20	9·8019735	257	0·1980265	9·8884444	173	0·1115556	9·9135291	429	10·0864709	40
21	9·8021276	257	0·1978724	9·8883408	173	0·1116592	9·9137868	429	10·0862132	39
22	9·8022816	256	0·1977184	9·8882372	173	0·1117628	9·9140444	429	10·0859556	38
23	9·8024355	256	0·1975645	9·8881335	173	0·1118665	9·9143020	429	10·0856980	37
24	9·8025894	256	0·1974106	9·8880298	173	0·1119702	9·9145596	429	10·0854404	36
25	9·8027431	256	0·1972569	9·8879260	173	0·1120740	9·9148171	429	10·0851829	35
26	9·8028968	256	0·1971032	9·8878221	173	0·1121779	9·9150747	429	10·0849253	34
27	9·8030504	256	0·1969496	9·8877182	173	0·1122818	6·9153322	429	10·0846678	33
28	9·8032038	256	0·1967962	9·8876142	173	0·1123858	9·9155896	429	10·0844104	32
29	9·8033572	255	0·1966428	9·8875102	173	0·1124898	9·9158471	429	10·0841529	31
30	9·8035105	255	0·1964895	9·8874061	174	0·1125939	9·9161045	429	10·0838955	30
31	9·8036637	255	0·1963363	9·8873019	174	0·1126981	9·9163618	429	10·0836382	29
32	9·8038168	255	0·1961832	9·8871977	174	0·1128023	9·9166192	429	10·0833808	28
33	9·8039699	255	0·1960301	9·8870934	174	0·1129066	9·9168766	429	10·0831235	27
34	9·8041228	255	0·1958772	9·8869890	174	0·1130110	9·9171338	429	10·0828662	26
35	9·8042757	255	0·1957243	9·8868846	174	0·1131154	9·9173911	429	10·0826089	25
36	9·8044284	254	0·1955716	9·8867801	174	0·1132199	9·9176483	429	10·0823517	24
37	9·8045811	254	0·1954189	9·8866756	174	0·1133244	9·9179055	429	10·0820945	23
38	9·8047336	254	0·1952664	9·8865710	174	0·1134290	9·9181627	429	10·0818373	22
39	9·8048861	254	0·1951139	9·8864665	174	0·1135337	9·9184198	428	10·0815802	21
40	9·8050385	254	0·1949615	9·8863616	175	0·1136384	9·9186769	428	10·0813231	20
41	9·8051908	254	0·1948092	9·8862566	175	0·1137432	9·9189340	428	10·0810660	19
42	9·8053430	253	0·1946570	9·8861519	175	0·1138481	9·9191911	428	10·0808089	18
43	9·8054951	253	0·1945049	9·8850470	175	0·1139530	9·9194481	428	10·0805519	17
44	9·8056472	253	0·1943528	9·8859420	175	0·1140580	9·9197051	428	10·0802949	16
45	9·8057991	253	0·1942009	9·8858370	175	0·1141630	9·9199621	428	10·0800379	15
46	9·8059510	253	0·1940490	9·8857319	175	0·1142681	9·9202191	428	10·0797809	14
47	9·8061027	253	0·1938973	9·8856267	175	0·1143733	9·9204760	428	10·0795240	13
48	9·8062544	252	0·1937456	9·8855215	175	0·1144785	9·9207329	428	10·0792671	12
49	9·8064060	252	0·1935940	9·8854162	175	0·1145838	9·9209898	428	10·0790102	11
50	9·8065575	252	0·1934425	9·8853109	175	0·1146891	9·9212466	428	10·0787534	10
51	9·8067089	252	0·1932911	9·8852055	176	0·1147945	9·9215034	428	10·0784966	9
52	9·8068602	252	0·1931398	9·8851000	176	0·1149000	9·9217602	428	10·0782398	8
53	9·8070114	252	0·1929886	9·8849945	176	0·1150055	9·9220170	428	10·0779830	7
54	9·8071626	252	0·1928374	9·8848889	176	0·1151111	9·9222737	428	10·0777263	6
55	9·8073136	252	0·1926864	9·8847832	176	0·1152168	9·9225304	428	10·0774696	5
56	9·8074646	251	0·1925354	9·8846775	176	0·1153225	9·9227871	428	10·0772129	4
57	9·8076154	251	0·1923846	9·8845717	176	0·1154283	9·9230437	428	10·0769563	3
58	9·8077662	251	0·1922338	9·8844659	176	0·1155341	9·9233004	428	10·0766996	2
59	9·8079169	251	0·1920831	9·8843599	177	0·1156401	9·9235570	427	10·0764430	1
60	9·8080675		0·1919325	9·8842540		0·1157460	9·9238135		10·0761865	0
	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10″	Comp. sec.	Cosine	D10″	Comp.cos.	Tangent	D10″	Cotangent	′
0	9·8080675	251	0·1919…	·8842540	177	0·1157460	9·9238135	428	10·0761865	60
1	9·8082180	251	0·1917…	9·8841479	177	0·1158521	9·9240701	427	10·0759299	59
2	9·8083684	251	0·1916…	9·8840418	177	0·1159582	9·9243266	427	10·0756734	58
3	9·8085188	250	0·191…	9·8839357	177	0·1160643	9·9245831	427	10·0754169	57
4	9·8086690	250	0·19…0	9·8838294	177	0·1161706	9·9248396	427	10·0751604	56
5	9·8088192	250	0·19…8	9·8837232	177	0·1162768	9·9250960	427	10·0749040	55
6	9·8089694	250	0·1…08	9·8836168	177	0·1163832	9·9253524	427	10·0746476	54
7	9·8091192	250	0·1…808	9·8835104	177	0·1164896	9·9256088	427	10·0743912	53
8	9·8092691	250	0·…309	9·8834039	178	0·1165961	9·9258652	427	10·0741348	52
9	9·8094189	250	0·…811	9·8832974	178	0·1167026	9·9261215	427	10·0738785	51
10	9·8095686	249	0·…04314	9·8831908	178	0·1168092	9·9263778	427	10·0736222	50
11	9·8097182	249	…02818	9·8830841	178	0·1169159	9·9266341	427	10·0733659	49
12	9·8098678	249	…901322	9·8829774	178	0·1170226	9·9268904	427	10·0731096	48
13	9·8100172	249	…899828	9·8828706	178	0·1171294	9·9271466	427	10·0728534	47
14	9·8101666	249	…1898334	9·8827638	178	0·1172362	9·9274028	427	10·0725972	46
15	9·8103159	249	0·1896841	9·8826568	178	0·1173432	9·9276590	427	10·0723410	45
16	9·8104650	24…	0·1895350	9·8825499	178	0·1174501	9·9279152	427	10·0720848	44
17	9·8106141	24…	0·1893859	9·8824428	178	0·1175572	9·9281713	427	10·0718287	43
18	9·8107631	2…	0·1892369	9·8823357	179	0·1176643	9·9284274	427	10·0715726	42
19	9·8109121	[illegible]	0·1890879	9·8822285	179	0·1177715	9·9286835	427	10·0713165	41
20	9·8110609	…8	0·1889391	9·8821213	179	0·1178787	9·9289396	427	10·0710604	40
21	9·811209…	48	0·1887904	9·8820140	179	0·1179860	9·9291956	427	10·0708044	39
22	9·811358…	48	0·1886417	9·8819067	179	0·1180933	9·9294516	427	10·0705484	38
23	9·81150…	248	0·1884931	9·8817992	179	0·1182008	9·9297076	427	10·0702924	37
24	9·81165…	247	0·1883446	9·8816918	179	0·1183082	9·9299636	427	10·0700364	36
25	9·81180…	247	0·1881962	9·8815842	179	0·1184158	9·9302195	427	10·0697805	35
26	9·8119…	247	0·1880479	9·8814766	179	0·1185234	9·9304755	426	10·0695245	34
27	9·812…3	247	0·1878997	9·8813689	179	0·1186311	9·9307314	426	10·0692686	33
28	9·812…84	247	0·1877516	9·8812612	180	0·1187388	9·9309872	426	10·0690128	32
29	9·81…65	247	0·1876035	9·8811534	180	0·1188466	9·9312431	426	10·0687569	31
30	9·81…44	246	0·1874556	9·8810455	180	0·1189545	9·9314989	426	10·0685011	30
31	9·8…6923	246	0·1873077	9·8809376	180	0·1190624	9·9317547	426	10·0682453	29
32	9·…28401	246	0·1871599	9·8808296	180	0·1191704	9·9320105	426	10·0679895	28
33	9·…29878	246	0·1870122	9·8807215	180	0·1192785	9·9322662	426	10·0677338	27
34	9…131354	246	0·1868646	9·8806134	180	0·1193866	9·9325220	426	10·0674780	26
35	…9132829	246	0·1867171	9·8805052	180	0·1194948	9·9327777	426	10·0672223	25
36	…8134303	246	0·1865697	9·8803970	180	0·1196030	9·9330334	426	10·0669666	24
37	…8135777	245	0·1864223	9·8802887	181	0·1197113	9·9332890	426	10·0667110	23
38	…8137250	245	0·1862750	9·8801803	181	0·1198197	9·9335446	426	10·0664554	22
39	…8138721	245	0·1861279	9·8800719	181	0·1199281	9·9338003	426	10·0661997	21
40	9·8140192	245	0·1859808	9·8799634	181	0·1200366	9·9340559	426	10·0659441	20
41	9·8141662	245	0·1858338	9·8798548	181	0·1201452	9·9343114	426	10·0656886	19
42	9·8143131	245	0·1856869	9·8797462	181	0·1202538	9·9345670	426	10·0654330	18
43	9·8144600	245	0·1855400	9·8796375	181	0·1203625	9·9348225	426	10·0651775	17
44	9·8146067	244	0·1853933	9·8795287	181	0·1204715	9·9350780	426	10·0649220	16
45	9·8147534	244	0·1852466	9·8794199	181	0·1205801	9·9353335	426	10·0646665	15
46	9·8148999	244	0·1851001	9·8793110	181	0·1206890	9·9355889	426	10·0644111	14
47	9·8150464	244	0·1849536	9·8792021	182	0·1207979	9·9358444	426	10·0641556	13
48	9·8151928	244	0·1848072	9·8790930	182	0·1209070	9·9360998	426	10·0639002	12
49	9·8153391	244	0·1846609	9·8789840	182	0·1210160	9·9363552	426	10·0636448	11
50	9·8154854	243	0·1845146	9·8788748	182	0·1211252	9·9366105	426	10·0633895	10
51	9·8156315	243	0·1843685	9·8787656	182	0·1212344	9·9368659	425	10·0631341	9
52	9·8157776	243	0·1842224	9·8786563	182	0·1213437	9·9371212	425	10·0628788	8
53	9·8159235	243	0·1840765	9·8785470	182	0·1214530	9·9373765	425	10·0626235	7
54	9·8160694	243	0·1839306	9·8784376	182	0·1215624	9·9376318	425	10·0623682	6
55	9·8162152	243	0·1837848	9·8783281	182	0·1216719	9·9378871	425	10·0621129	5
56	9·8163609	243	0·1836391	9·8782186	183	0·1217814	9·9381423	425	10·0618577	4
57	9·8165066	242	0·1834934	9·8781090	183	0·1218910	9·9383975	425	10·0616025	3
58	9·8166521	242	0·1833479	9·8779994	183	0·1220006	9·9386527	425	10·0613473	2
59	9·8167975	242	0·1832025	9·8778896	183	0·1221104	9·9389079	425	10·0610921	1
60	9·8169429		0·1830571	9·8777799		0·1222201	9·9391631		10·0608369	0
′	Cosine	D10″	Comp.cos.	Sine	D10″	Comp.sin.	Cotang.	D10″	Tangent	′

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′	Sine	D10″	Comp. sec.	Cosine	D10″	Comp. sec.	Tang.	D10″	Cotangent	′
0	9·8169429	242	0·1830571	9·8777[illegible]	183	0·1222301	9·93[illegible]		10·0608369	60
1	9·8170882	242	0·1829118	9·87767[illegible]	183	0·1223300	9·939[illegible]	425	10·0605815	59
2	9·81723[illegible]	242	0·1827666	9·8775601	183	0·1224399	9·939[illegible]	425	10·0603267	58
3	9·8173785	242	0·1826215	9·8771501	183	0·1225499	9·93[illegible]	425	10·0600716	57
4	9·8175235	242	0·182476[illegible]	9·8773401	183	0·122659[illegible]	9·9401[illegible]	425	10·0598163	56
5	9·8176685	241	0·18233[illegible]	9·8772300	184	0·1227700	9·9404[illegible]	425	10·0595616	55
6	9·81784[illegible]	241	0·1821867	9·8771198	184	0·1228802	9·94069[illegible]	425	10·0593064	54
7	9·8179581	241	0·1820419	9·8770096	184	0·1229904	9·94094[illegible]		10·0590514	53
8	9·8181028	241	0·18189[illegible]	9·876899[illegible]	184	0·1231007	9·94120[illegible]	425	10·0587964	52
9	9·8182474	241	0·1817526	9·8767884	184	0·1232111	9·94145[illegible]		10·0585415	51
10	9·8183919	241	0·1816081	9·87667[illegible]	184	0·1233215	9·941713[illegible]		10·0582865	50
11	9·818536[illegible]	240	0·1814636	9·87656[illegible]	184	0·1234320	9·9419664	4	10·0580316	49
12	9·8186807	240	0·1813193	9·8764574	184	0·123[illegible]426	9·9422233	4	10·0577767	48
13	9·8188250	240	0·1811[illegible]	9·8763468	184	0·1236532	9·9424782	42	10·057[illegible]218	47
14	9·8189692	240	0·1810308	9·8762361	185	0·1237639	9·942733[illegible]	42	10·0572669	46
15	9·8191133	240	0·1808867	9·876125[illegible]	18[illegible]	0·1238747	9·9429879	425	10·0570121	45
16	9·8192575	240	0·1807427	9·876014[illegible]	18[illegible]	0·1239855	9·943[illegible]	425	10·05675[illegible]	44
17	9·8194012	240	0·1805988	9·8758[illegible]	18[illegible]	0·1240964	9·943[illegible]	425	10·05[illegible]	43
18	9·8195450	240	0·18045[illegible]	9·8757927	18[illegible]	0·1242073	9·943752[illegible]	425	10·0562476	42
19	9·8196888	239	0·1803112	9·875681[illegible]	18[illegible]	0·1243181	9·94400[illegible]	424	10·0559928	41
20	9·8198325	239	0·180167[illegible]	9·8755706	185	0·1244294	9·9442619	424	10·0557381	40
21	9·819976[illegible]	23[illegible]	0·1800239	9·875459[illegible]	18[illegible]	0·1245406	9·9445166	424	10·[illegible]4834	39
22	9·8201196	239	0·1798804	9·875548[illegible]	18[illegible]	0·1246518	9·9447714	424	10·[illegible]286	38
23	9·8202630	239	0·1797370	9·875236[illegible]	185	0·1247631	9·94[illegible]0261	424	10·[illegible]	37
24	9·820406[illegible]	239	0·1795937	9·8751256	186	0·1248744	9·9452807	424	10·0[illegible]19[illegible]	36
25	9·8205496	239	0·1794504	9·875014[illegible]	186	0·1249855	9·9455354	424	10·05[illegible]46	35
26	9·820692[illegible]	238	0·179[illegible]073	9·8749027	186	0·125097[illegible]	9·945790[illegible]	424	10·05[illegible]0[illegible]	34
27	9·82093[illegible]	238	0·179[illegible]642	9·87471[illegible]	186	0·12[illegible]2068	9·9460447	424	10·05[illegible]53	33
28	9·8209788	238	0·179[illegible]12	9·874679[illegible]	186	0·12[illegible]	9·9462993	424	10·053[illegible]	32
29	9·8211217	238	0·17887[illegible]	9·874[illegible]679	186	0·1254321	9·94655[illegible]9	424	10·0[illegible]34[illegible]	31
30	9·8212646	238	0·1787354	9·8744561	186	0·125[illegible]439	9·946808[illegible]	424	10·0531[illegible]	30
31	9·821[illegible]073	238	0·1785927	9·8743[illegible]	187	0·125[illegible]7	9·947[illegible]	424	10·05[illegible]	29
32	9·8215500	238	0·1784[illegible]	9·87423[illegible]	187	0·12[illegible]	9·9473[illegible]	424	10·05[illegible]	28
33	9·821[illegible]926	237	0·178[illegible]	9·87412[illegible]	187	0·12[illegible]	9·94[illegible]0	424	10·0524286	27
34	9·8218351	237	0·1781649	9·8741008	187	0·12[illegible]	9·94782[illegible]	424	10·05217[illegible]	26
35	9·82197[illegible]	237	0·17[illegible]02[illegible]	9·873896[illegible]	187	0·12610[illegible]	9·9480810	424	10·0519190	25
36	9·8221198	237	0·17788[illegible]2	9·87[illegible]544	187	0·126213[illegible]	9·948[illegible]	424	10·0516645	24
37	9·8222621	237	0·177[illegible]	9·8[illegible]072	187	0·12[illegible]3278	9·94[illegible]	424	10·0514101	23
38	9·8224049	237	0·1775956	9·87[illegible]	187	0·1264401	9·948844[illegible]	424	10·0[illegible]1[illegible]57	22
39	9·8225463	237	0·17745[illegible]37	9·87[illegible]	187	0·12[illegible]524	9·949098[illegible]	424	10·050[illegible]01	21
40	9·822[illegible]88[illegible]	237	0·17731[illegible]	9·87[illegible]3	187	0·126[illegible]8	9·94[illegible]31	424	10·0[illegible]0[illegible]46	20
41	9·822[illegible]	236	0·17710[illegible]	9·87322[illegible]	187	0·12[illegible]	9·94[illegible]	424	10·0[illegible]	19
42	9·8229721	236	0·17702[illegible]	9·87[illegible]110	188	0·12[illegible]	9·9498619	424	10·050[illegible]81	18
43	9·8231138	236	0·17658[illegible]2	9·87297[illegible]	188	0·12[illegible]00[illegible]	9·9501[illegible]2	424	10·049[illegible]	17
44	9·8232555	236	0·170[illegible]45	9·87[illegible]88[illegible]	188	0·12711[illegible]1	9·9503705	424	10·04[illegible]629[illegible]	16
45	9·8233971	236	0·1766029	9·872772[illegible]	188	0·12[illegible]	9·9506[illegible]45	424	10·04[illegible]	15
46	9·8235386	236	0·176[illegible]14	9·8720[illegible]	188	0·127[illegible]406	9·950[illegible]	424	10·0491209	14
47	9·823680[illegible]	235	0·17[illegible]200	9·87[illegible]	188	0·1274[illegible]	9·95113[illegible]	424	10·048[illegible]	13
48	9·823821[illegible]	235	0·176178[illegible]	9·87[illegible]	188	0·127[illegible]	9·951[illegible]	424	10·0486124	12
49	9·823962[illegible]	235	0·1760[illegible]74	9·872320[illegible]	188	0·127[illegible]	9·9516419	424	10·0483581	11
50	9·824[illegible]	235	0·17[illegible]	9·8722070	189	0·12[illegible]924	9·9518961	424	10·0481039	10
51	9·8247448	235	0·17[illegible]	9·872094[illegible]	189	0·12790[illegible]5	9·9521503	424	10·0478497	9
52	9·824[illegible]	235	0·17[illegible]6142	9·8719813	189	0·1280187	9·9524045	424	10·0475955	8
53	9·824[illegible]267	235	0·1754733	9·87186[illegible]	189	0·1281319	9·952[illegible]587	424	10·0473413	7
54	9·8246676	235	0·175[illegible]24	9·87[illegible]	189	0·128[illegible]	9·9529128	424	10·0470872	6
55	9·8248083	234	0·1751917	9·87[illegible]6414	189	0·128[illegible]6	9·9531670	423	10·046[illegible]30	5
56	9·8249[illegible]	234	0·1750[illegible]10	9·871527[illegible]	189	0·1284721	9·95[illegible]4211	423	10·0465789	4
57	9·82[illegible]96	234	0·1749104	9·8714144	189	0·1285[illegible]	9·95[illegible]	423	10·046[illegible]245	3
58	9·825[illegible]01	234	0·1747690	9·871301[illegible]	189	0·1286902	9·9539[illegible]	423	10·04[illegible]0707	2
59	9·825770[illegible]	234	0·174629[illegible]	9·8711872	189	0·1288128	9·9541834	423	10·0458160	1
60	9·825[illegible]109		0·1744891	9·871073[illegible]		0·129[illegible]265	9·9544374		10·04[illegible]5[illegible]26	0
	Cosine	[illegible]	Comp. sec.	Sine	D10″	Comp. sec.	Cotang.	D10	Tangent	′

Tab. 18. Deg 48.

′	Sine	D10″	Comp. sin	Cosine	D10″	Comp. cos	Tangent	D10″	Cotangent	′
0	9·8255109	234	0·1744891	9·8710735	190	0·1289265	9·9544374	423	10·0455626	60
1	9·8256512	234	0·1743488	9·8709597	190	0·1290403	9·9546915	423	10·0453085	59
2	9·8257913	233	0·1742087	9·8708458	190	0·1291542	9·9549455	423	10·0450545	58
3	9·8259314	233	0·1740686	9·8707319	190	0·1292681	9·9551995	423	10·0448005	57
4	9·8260715	233	0·1739285	9·8706179	190	0·1293821	9·9554535	423	10·0445465	56
5	9·8262114	233	0·1737886	9·8705039	190	0·1294961	9·9557075	423	10·0442925	55
6	9·8263512	233	0·1736488	9·8703898	190	0·1296102	9·9559615	423	10·0440385	54
7	9·8264910	233	0·1735090	9·8702756	190	0·1297244	9·9562154	423	10·0437846	53
8	9·8266307	233	0·1733693	9·8701613	190	0·1298387	9·9564694	423	10·0435306	52
9	9·8267703	232	0·1732297	9·8700470	190	0·1299530	9·9567233	423	10·0432767	51
10	9·8269098	232	0·1730902	9·8699326	191	0·1300674	9·9569772	423	10·0430228	50
11	9·8270493	232	0·1729507	9·8698182	191	0·1301818	9·9572311	423	10·0427689	49
12	9·8271887	232	0·1728113	9·8697037	191	0·1302963	9·9574850	423	10·0425150	48
13	9·8273279	232	0·1726721	9·8695891	191	0·1304109	9·9577389	423	10·0422611	47
14	9·8274671	232	0·1725329	9·8694744	191	0·1305256	9·9579927	423	10·0420073	46
15	9·8276063	232	0·1723937	9·8693597	191	0·1306403	9·9582465	423	10·0417535	45
16	9·8277453	232	0·1722547	9·8692449	191	0·1307551	9·9585004	423	10·0414996	44
17	9·8278843	231	0·1721157	9·8691301	191	0·1308699	9·9587542	423	10·0412458	43
18	9·8280231	231	0·1719769	9·8690152	192	0·1309848	9·9590080	423	10·0409920	42
19	9·8281619	231	0·1718381	9·8689002	192	0·1310998	9·9592617	423	10·0407383	41
20	9·8283006	231	0·1716994	9·8687851	192	0·1312149	9·9595155	423	10·0404845	40
21	9·8284393	231	0·1715607	9·8686700	192	0·1313300	9·9597693	423	10·0402307	39
22	9·8285778	231	0·1714222	9·8685548	192	0·1314452	9·9600230	423	10·0399770	38
23	9·8287163	231	0·1712837	9·8684396	192	0·1315604	9·9602767	423	10·0397233	37
24	9·8288547	230	0·1711453	9·8683242	192	0·1316758	9·9605305	423	10·0394695	36
25	9·8289930	230	0·1710070	9·8682088	192	0·1317912	9·9607842	423	10·0392158	35
26	9·8291312	230	0·1708688	9·8680934	192	0·1319066	9·9610378	423	10·0389622	34
27	9·8292694	230	0·1707306	9·8679779	193	0·1320221	9·9612915	423	10·0387085	33
28	9·8294075	230	0·1705925	9·8678623	193	0·1321377	9·9615452	423	10·0384548	32
29	9·8295454	230	0·1704546	9·8677466	193	0·1322534	9·9617988	423	10·0382012	31
30	9·8296833	230	0·1703167	9·8676309	193	0·1323691	9·9620525	423	10·0379475	30
31	9·8298212	229	0·1701788	9·8675151	193	0·1324849	9·9623061	423	10·0376939	29
32	9·8299589	229	0·1700411	9·8673992	193	0·1326008	9·9625597	423	10·0374403	28
33	9·8300966	229	0·1699034	9·8672833	193	0·1327167	9·9628133	423	10·0371867	27
34	9·8302342	229	0·1697658	9·8671673	193	0·1328327	9·9630669	423	10·0369331	26
35	9·8303717	229	0·1696283	9·8670512	193	0·1329488	9·9633204	423	10·0366796	25
36	9·8305091	229	0·1694909	9·8669351	194	0·1330649	9·9635740	423	10·0364260	24
37	9·8306464	229	0·1693536	9·8668189	194	0·1331811	9·9638275	423	10·0361725	23
38	9·8307837	229	0·1692163	9·8667026	194	0·1332974	9·9640811	422	10·0359189	22
39	9·8309209	228	0·1690791	9·8665863	194	0·1334137	9·9643346	422	10·0356654	21
40	9·8310580	228	0·1689420	9·8664699	194	0·1335301	9·9645881	422	10·0354119	20
41	9·8311950	228	0·1688050	9·8663534	194	0·1336466	9·9648416	422	10·0351584	19
42	9·8313320	228	0·1686680	9·8662369	194	0·1337631	9·9650951	422	10·0349049	18
43	9·8314688	228	0·1685312	9·8661203	194	0·1338797	9·9653486	422	10·0346514	17
44	9·8316056	228	0·1683944	9·8660036	195	0·1339964	9·9656020	422	10·0343980	16
45	9·8317423	228	0·1682577	9·8658868	195	0·1341132	9·9658555	422	10·0341445	15
46	9·8318789	228	0·1681211	9·8657700	195	0·1342300	9·9661089	422	10·0338911	14
47	9·8320155	227	0·1679845	9·8656531	195	0·1343469	9·9663623	422	10·0336377	13
48	9·8321519	227	0·1678481	9·8655362	195	0·1344638	9·9666157	422	10·0333843	12
49	9·8322883	227	0·1677117	9·8654192	195	0·1345808	9·9668692	422	10·0331308	11
50	9·8324246	227	0·1675754	9·8653021	195	0·1346979	9·9671225	422	10·0328775	10
51	9·8325609	227	0·1674391	9·8651849	195	0·1348151	9·9673759	422	10·0326241	9
52	9·8326970	227	0·1673030	9·8650677	195	0·1349323	9·9676293	422	10·0323707	8
53	9·8328331	226	0·1671669	9·8649504	195	0·1350496	9·9678827	422	10·0321173	7
54	9·8329691	226	0·1670309	9·8648331	196	0·1351669	9·9681360	422	10·0318640	6
55	9·8331050	226	0·1668950	9·8647156	196	0·1352844	9·9683893	422	10·0316107	5
56	9·8332408	226	0·1667592	9·8645981	196	0·1354019	9·9686427	422	10·0313573	4
57	9·8333766	226	0·1666234	9·8644806	196	0·1355194	9·9688960	422	10·0311040	3
58	9·8335122	226	0·1664878	9·8643629	196	0·1356371	9·9691493	422	10·0308507	2
59	9·8336478	226	0·1663522	9·8642452	196	0·1357548	9·9694026	422	10·0305974	1
60	9·8337833		0·1662167	9·8641275		0·1358725	9·9696559		10·0303441	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

43 Deg. Tab. 18.

′	Sine	D10″	Comp. sin.	Cosine	D10″	Comp. cos.	Tangent	D10″	Cotangent	′
0	9·8337833	226	0·1662167	9·8641275	196	0·1358725	9·9696559	422	10·0303441	60
1	9·8339188	226	0·1660812	9·8640096	196	0·1359904	9·9698091	422	10·0300909	59
2	9·8340541	225	0·1659459	9·8638917	197	0·1361083	9·9701624	422	10·0298376	58
3	9·8341894	225	0·1658106	9·8637737	197	0·136226	9·9704157	422	10·0295843	57
4	9·8343246	225	0·1656754	9·8636557	197	0·1363443	9·9706689	422	10·0293311	56
5	9·8344597	225	0·1655403	9·8635376	197	0·1364624	9·9709221	422	10·0290779	55
6	9·8345948	225	0·1654052	9·8634194	197	0·1365806	9·9711754	422	10·0288246	54
7	9·8347297	225	0·1652703	9·8633011	197	0·1366989	9·9714286	422	10·0285714	53
8	9·8348646	225	0·1651354	9·8631828	197	0·1368172	9·9716818	422	10·0283182	52
9	9·8349994	224	0·1650006	9·8630644	197	0·1369356	9·9719350	422	10·0280650	51
10	9·8351341	224	0·1648659	9·8629460	198	0·1370540	9·9721882	422	10·0278118	50
11	9·8352688	224	0·1647312	9·8628274	198	0·1371726	9·9724413	422	10·0275587	49
12	9·8354033	224	0·1645967	9·8627088	198	0·1372912	9·9726945	422	10·0273055	48
13	9·8355378	224	0·1644622	9·8625902	198	0·1374098	9·9729477	422	10·0270523	47
14	9·8356722	224	0·1643278	9·8624714	198	0·1375286	9·9732008	422	10·0267992	46
15	9·8358066	224	0·1641934	9·8623526	198	0·1376474	9·9734539	422	10·0265461	45
16	9·8359408	224	0·1640592	9·8622338	198	0·1377662	9·9737071	422	10·0262929	44
17	9·8360750	224	0·1639250	9·8621148	198	0·1378852	9·9739602	422	10·0260398	43
18	9·8362091	223	0·1637909	9·8619958	198	0·1380042	9·9742133	422	10·0257867	42
19	9·8363431	223	0·1636569	9·8618767	198	0·1381233	9·9744664	422	10·0255336	41
20	9·8364771	223	0·1635229	9·8617576	199	0·1382424	9·9747195	422	10·0252805	40
21	9·8366109	223	0·1633891	9·8616383	199	0·1383617	9·9749726	422	10·0250274	39
22	9·8367447	223	0·1632553	9·8615190	199	0·1384810	9·9752257	422	10·0247743	38
23	9·8368784	223	0·1631216	9·8613997	199	0·1386003	9·9754787	422	10·0245213	37
24	9·8370121	223	0·1629879	9·8612803	199	0·1387197	9·9757318	422	10·0242682	36
25	9·8371456	222	0·1628544	9·8611608	199	0·1388392	9·9759849	422	10·0240151	35
26	9·8372791	222	0·1627209	9·8610412	199	0·1389588	9·9762379	422	10·0237621	34
27	9·8374125	222	0·1625875	9·8609215	199	0·1390785	9·9764909	422	10·0235091	33
28	9·8375458	222	0·1624542	9·8608018	199	0·1391982	9·9767440	422	10·0232560	32
29	9·8376790	222	0·1623210	9·8606821	200	0·1393179	9·9769970	422	10·0230030	31
30	9·8378122	222	0·1621878	9·8605622	200	0·1394378	9·9772500	422	10·0227500	30
31	9·8379453	222	0·1620547	9·8604423	200	0·1395577	9·9775030	422	10·0224970	29
32	9·8380783	221	0·1619217	9·8603223	200	0·1396777	9·9777560	422	10·0222440	28
33	9·8382112	221	0·1617888	9·8602022	200	0·1397978	9·9780090	422	10·0219910	27
34	9·8383441	221	0·1616559	9·8600821	200	0·1399179	9·9782620	422	10·0217380	26
35	9·8384769	221	0·1615231	9·8599619	200	0·1400381	9·9785149	422	10·0214851	25
36	9·8386096	221	0·1613904	9·8598416	200	0·1401584	9·9787679	422	10·0212321	24
37	9·8387422	221	0·1612578	9·8597213	201	0·1402787	9·9790209	422	10·0209791	23
38	9·8388747	221	0·1611253	9·8596009	201	0·1403991	9·9792738	422	10·0207262	22
39	9·8390072	221	0·1609928	9·8594804	201	0·1405196	9·9795268	422	10·0204732	21
40	9·8391396	220	0·1608604	9·8593599	201	0·1406401	9·9797797	421	10·0202203	20
41	9·8391719	220	0·1607281	9·8592393	201	0·1407607	9·9800326	421	10·0199674	19
42	9·8394041	220	0·1605959	9·8591186	201	0·1408814	9·9802856	421	10·0197144	18
43	9·8395363	220	0·1604637	9·8589978	201	0·1410022	9·9805385	421	10·0194615	17
44	9·8396684	220	0·1603316	9·8588770	201	0·1411230	9·9807914	421	10·0192086	16
45	9·8398004	220	0·1601996	9·8587561	202	0·1412439	9·9810443	421	10·0189557	15
46	9·8399323	220	0·1600677	9·8586351	202	0·1413649	9·9812972	421	10·0187028	14
47	9·8400642	219	0·1599358	9·8585141	202	0·1414859	9·9815501	421	10·0184499	13
48	9·8401959	219	0·1598041	9·8583929	202	0·1416071	9·9818030	421	10·0181970	12
49	9·8403276	219	0·1596724	9·8582718	202	0·1417282	9·9820559	421	10·0179441	11
50	9·8404593	219	0·1595407	9·8581505	202	0·1418495	9·9823087	421	10·0176913	10
51	9·8405908	219	0·1594092	9·8580292	202	0·1419708	9·9825616	421	10·0174384	9
52	9·8407223	219	0·1592777	9·8579078	202	0·1420922	9·9828145	421	10·0171855	8
53	9·8408537	219	0·1591463	9·8577863	202	0·1422137	9·9830673	421	10·0169327	7
54	9·8409850	219	0·1590150	9·8576648	202	0·1423352	9·9833202	421	10·0166798	6
55	9·8411162	219	0·1588838	9·8575432	203	0·1424568	9·9835730	421	10·0164270	5
56	9·8412474	218	0·1587526	9·8574215	203	0·1425785	9·9838259	421	10·0161741	4
57	9·8413785	218	0·1583215	9·8572998	203	0·1427002	9·9840787	421	10·0159213	3
58	9·8415095	218	0·1584905	9·8571779	203	0·1428221	9·9843315	421	10·0156685	2
59	9·8416404	218	0·1583596	9·8570561	203	0·1429439	9·9845844	421	10·0154156	1
60	9·8417713		0·1582287	9·8569341		0·1430659	9·9848372		10·0151628	0
′	Cosine	D10″	Comp. cos.	Sine	D10″	Comp. sin.	Cotang.	D10″	Tangent	′

′	Sine	D10	Comp sin	Cosine	D10″	Comp cos	Tangent	D10″	Cotangent	′
0	9·8417718	218	0·1582287	9·8569544	203	0·1430659	9·9848372	421	10·0151628	60
1	9·8419021	218	0·1580979	9·8568121	203	0·1431879	9·9850900	421	10·0149100	59
2	9·8420328	218	0·1579672	9·8566900	204	0·1433100	9·9853428	421	10·0146572	58
3	9·8421634	217	0·1578366	9·8565678	204	0·1434322	9·9855956	421	10·0144044	57
4	9·8422939	217	0·1577061	9·8564455	204	0·1435545	9·9858484	421	10·0141516	56
5	9·8424244	217	0·1575756	9·8563232	204	0·1436768	9·9861012	421	10·0138988	55
6	9·8425548	217	0·1574452	8562008	204	0·1437992	9·9863540	421	10·0136460	54
7	9·8426851	217	0·1573149	8560784	204	0·1439216	9·9866068	421	10·0133932	53
8	9·8428154	217	0·1571846	9·8559558	204	0·1440442	9·9868596	421	10·0131404	52
9	9·8429456	217	0·1570544	9·8558332	204	0·1441668	9·9871123	421	10·0128877	51
10	9·8430757	217	0·1569243	9·8557106	205	0·1442894	9·9873651	421	10·0126349	50
11	9·8432057	216	0·1567943	9·8555878	205	0·1444122	9·9876179	421	10·0123821	49
12	9·8433356	216	0·1566644	9·8554650	205	0·1445350	9·9878706	421	10·0121294	48
13	9·8434655	216	0·1565345	9·8553421	205	0·1446579	9·9881234	421	10·0118766	47
14	9·8435953	216	0·1564047	9·8552192	205	0·1447808	9·9883761	421	10·0116239	46
15	9·8437250	216	0·1562750	9·8550961	205	0·1449039	9·9886289	421	10·0113711	45
16	9·8438547	216	0·1561453	9·8549730	205	0·1450270	9·9888816	421	10·0111184	44
17	9·8439842	216	0·1560158	9·8548499	205	0·1451501	9·9891344	421	10·0108656	43
18	9·8441137	216	0·1558863	9·8547266	205	0·1452734	9·9893871	421	10·0106129	42
19	9·8442432	215	0·1557568	9·8546033	206	0·1453967	9·9896399	421	10·0103601	41
20	9·8443725	215	0·1556275	9·8544799	206	0·1455201	9·9898926	421	10·0101074	40
21	9·8445018	215	0·1554982	9·8543564	206	0·1456436	9·9901453	421	10·0098547	39
22	9·8446310	215	0·1553690	9·8542329	206	0·1457671	9·9903981	421	10·0096019	38
23	9·8447601	215	0·1552399	9·8541093	206	0·1458907	9·9906508	421	10·0093492	37
24	9·8448891	215	0·1551109	9·8539856	206	0·1460144	9·9909035	421	10·0090965	36
25	9·8450181	215	0·1549819	9·8538619	206	0·1461381	9·9911562	421	10·0088438	35
26	9·8451470	215	0·1548530	9·8537381	206	0·1462619	9·9914089	421	10·0085911	34
27	9·8452758	214	0·1547242	9·8536142	207	0·1463858	9·9916616	421	10·0083384	33
28	9·8454045	214	0·1545955	9·8534902	207	0·1465098	9·9919143	421	10·0080857	32
29	9·8455332	214	0·1544668	9·8533662	207	0·1466338	9·9921670	421	10·0078330	31
30	9·8456618	214	0·1543382	9·8532421	207	0·1467579	9·9924197	421	10·0075803	30
31	9·8457903	214	0·1542097	9·8531179	207	0·1468821	9·9926724	421	10·0073276	29
32	9·8459188	214	0·1540812	9·8529936	207	0·1470064	9·9929251	421	10·0070749	28
33	9·8460471	214	0·1539529	9·8528693	207	0·1471307	9·9931778	421	10·0068222	27
34	9·8461754	214	0·1538246	9·8527449	207	0·1472551	9·9934305	421	10·0065695	26
35	9·8463036	214	0·1536964	9·8526204	207	0·1473796	9·9936832	421	10·0063168	25
36	9·8464318	213	0·1535682	9·8524959	208	0·1475041	9·9939359	421	10·0060641	24
37	9·8465599	213	0·1534401	9·8523713	208	0·1476287	9·9941886	421	10·0058114	23
38	9·8466879	213	0·1533121	9·8522466	208	0·1477534	9·9944413	421	10·0055587	22
39	9·8468158	213	0·1531842	9·8521218	208	0·1478782	9·9946940	421	10·0053060	21
40	9·8469436	213	0·1530564	9·8519970	208	0·1480030	9·9949466	421	10·0050534	20
41	9·8470714	213	0·1529286	9·8518721	208	0·1481279	9·9951993	421	10·0048007	19
42	9·8471991	213	0·1528009	9·8517471	208	0·1482529	9·9954520	421	10·0045480	18
43	9·8473267	213	0·1526733	9·8516220	208	0·1483780	9·9957047	421	10·0042953	17
44	9·8474543	212	0·1525457	9·8514969	209	0·1485031	9·9959573	421	10·0040427	16
45	9·8475817	212	0·1524183	9·8513717	209	0·1486283	9·9962100	421	10·0037900	15
46	9·8477091	212	0·1522909	9·8512465	209	0·1487535	9·9964627	421	10·0035373	14
47	9·8478365	212	0·1521635	9·8511211	209	0·1488789	9·9967154	421	10·0032846	13
48	9·8479637	212	0·1520363	9·8509957	209	0·1490043	9·9969680	421	10·0030320	12
49	9·8480909	212	0·1519091	9·8508702	209	0·1491298	9·9972207	421	10·0027793	11
50	9·8482180	212	0·1517820	9·8507446	209	0·1492554	9·9974734	421	10·0025266	10
51	9·8483450	212	0·1516550	9·8506190	209	0·1493810	9·9977260	421	10·0022740	9
52	9·8484720	211	0·1515280	9·8504933	210	0·1495067	9·9979787	421	10·0020213	8
53	9·8485989	211	0·1514011	9·8503675	210	0·1496325	9·9982314	421	10·0017686	7
54	9·8487257	211	0·1512743	9·8502417	210	0·1497583	9·9984840	421	10·0015160	6
55	9·8488524	211	0·1511476	9·8501157	210	0·1498843	9·9987367	421	10·0012633	5
56	9·8489791	211	0·1510209	9·8499897	210	0·1500103	9·9989893	421	10·0010107	4
57	9·8491057	211	0·1508943	9·8498637	210	0·1501363	9·9992420	421	10·0007580	3
58	9·8492322	211	0·1507678	9·8497375	210	0·1502625	9·9994947	421	10·0005053	2
59	9·8493586	211	0·1506414	9·8496113	210	0·1503887	9·9997473	421	10·0002527	1
60	9·8494850		0·1505150	9·8494850		0·1505150	10·0000000		10·0000000	0
′	Cosine	D10″	Comp cos	Sine	D10″	Comp sin	Cotang.	D10″	Tangent	′

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